RED Lanes Study

FINAL REPORT

June 2020

NC Capital Area Metropolitan Planning Organization

RENAISSANCE PLANNING

Executive Summary

RED Lanes Overview

The Capital Area Metropolitan Planning Organization (CAMPO) has undertaken the RED Lanes Study to identify opportunities to enhance regional mobility though RED Lane transit priority treatments, document best practices for their implementation, and share data and analysis resources for further evaluation and development of potential RED Lane projects.

Bus priority lanes can be implemented in a variety of ways and in a variety of contexts. Other users, like bicycles, taxis, and emergency vehicles can use the lanes. Pavement markings, posted speeds, and parking restrictions vary. (Source: Greater Greater Washington)

A RED Lane is a transit-priority travel lane with restrictions for other modes. Buses typically share RED Lanes with right turning cars, emergency vehicles, and driveway access. The primary objective of RED Lanes is to optimize bus operations in a corridor to maximize transit competitiveness, reliability, and ridership through the dedication of right-of-way (ROW). RED Lanes also aim to minimize disruption to drivers by sharing the dedicated lane space with turning vehicles and emergency services.

The RED acronym highlights these typical characteristics of the transit priority lanes and reflects the frequent application of red surface treatments to demarcate transit lanes from general use traffic lanes. Although the acronym emphasizes the potential for RED Lanes to share space with other motor vehicles, bicycles are also sometimes allowed in transit lanes and a variety of design options are available for implementation that may exclude some or all shared uses. RED Lanes are sometimes referred to as business access and transit (BAT) lanes or simply transit priority lanes.

RED Lanes can be a key part of achieving the regional vision for transportation set forth in CAMPO's 2045 Metropolitan Transportation Plan (MTP). They present low-cost strategic projects that improve transit speed and reliability, supporting the investments in commuter rail, light rail, bus rapid transit (BRT), and high-frequency fixed-route bus services envisioned in the MTP. They are also consistent with the Freeway and Street-based Transit ("FAST") network plan developed by the Regional Transportation Alliance (RTA) in coordination with GoTriangle and NCDOT. The FAST plan aims to accelerate the creation of a complete transit network to better connect the entire Triangle area while improving accessibility.

The RED Lanes study provides resources to decision-makers and planners throughout the CAMPO region to guide RED Lane suitability assessment, project development, and implementation.

Components of the RED Lanes Study

Through the RED Lanes Study, CAMPO has developed several resources to support RED Lane analysis, project development, and implementation by partner agencies.

Analysis is facilitated through the ***RED Lanes Toolkit***, an ArcGIS-based toolkit for analyzing where RED Lanes are suitable and what design features and/or accompanying operational treatments may be appropriate. The Toolkit was used to produce an initial assessment of RED Lanes suitability across the region (see Appendix A) and will be made available to partner agencies to support local analyses and scenario testing. The Toolkit and the suitability analysis process are thoroughly documented in the ***RED Lanes Evaluation Methodology Report*** (Report 4) and the ***RED Lanes Toolkit User Guide*** (Report 5). CAMPO envisions making periodic updates to the Toolkit to utilize fresh data and/or revise the suitability methodology as warranted.

The Toolkit combines several regional and national data sources in the analysis workflow shown in Figure i. The RED Lanes Suitability analysis component assesses key indicators of the appropriateness of transit priority treatments across four major dimensions: travel demand, transit operations, highway operations, context/design. These suitability scores are then combined with demographic data and indicators of RED Lanes feasibility in the prioritization phase. This phase does not determine the final priority of particular segments for RED Lanes projects but helps differentiate suitable segments based on considerations of demographic equity and expected project feasibility. Finally, the implementation phase generates indicators that help guide appropriate components to consider in developing a RED Lanes project, including the need to design the facility to accommodate bicyclists and pedestrians, whether to consider transit signal priority (TSP) improvements as part of the project, and whether RED Lane restrictions need to be enforced at all times of day or only during peak travel periods.

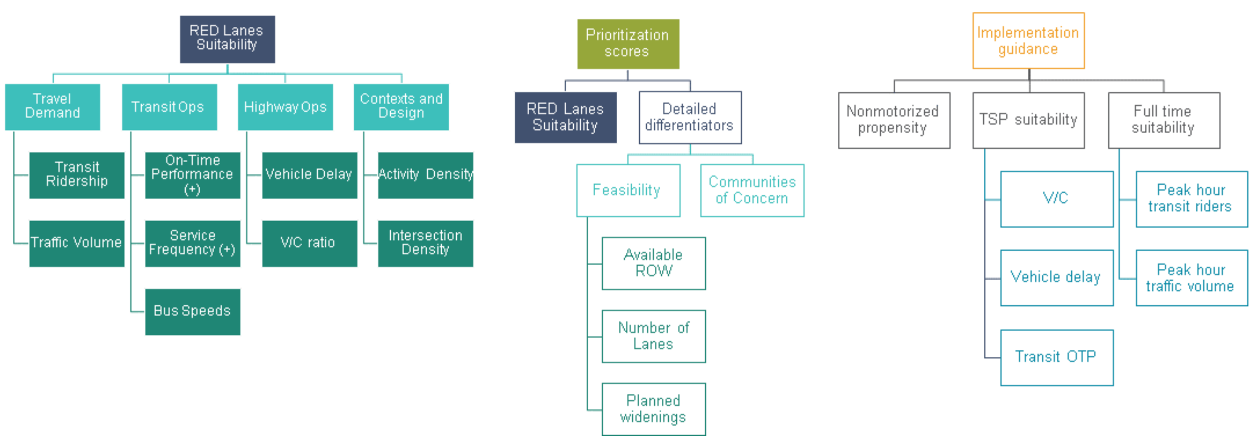

Figure i: RED Lanes Analysis Workflow: Linking Suitability, Prioritization, and Implementation

In addition to these analytical resources, the RED Lanes Study includes documents to guide RED Lanes planning. The ***RED Lanes Fundamentals Report*** (Report 1) outlines the design and operational characteristics of RED Lanes, summarizes industry literature about RED Lanes and transit priority treatments, and discusses 10 case studies from across the country. It highlights the importance of strong regional partnerships, clear policy frameworks, and focus on a selection of key metrics to effectively evaluate and plan for RED Lanes projects. The ***Key Plans in the CAMPO Region*** (Report 2) report reviews relevant plans in the CAMPO region to understand key policy emphases related to multimodal travel, placemaking, and transit mobility. Together, these documents inform the RED Lanes evaluation methodology and contextualize results, ground potential RED Lanes projects in best practices and regional planning emphases, and introduce common design and operational treatments accompanying RED Lanes.

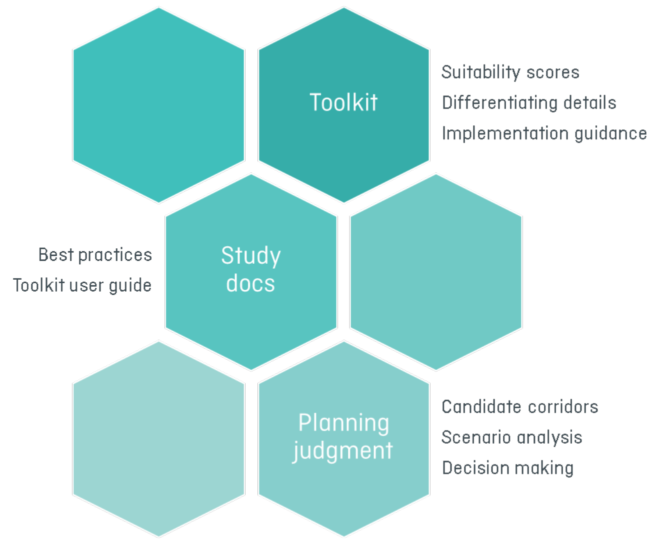

Figure ii Elements of RED Lanes Planning

Finally, to guide the interpretation of RED Lanes analysis results and facilitate project development, the ***Scoping Sheet Menu*** (Appendix B) frames interpretation for initial scoping of a RED Lane project study. The menu helps planners identify several key design, operations, and cost elements for consideration in RED Lanes implementation. These are itemized in ***Candidate Corridor Scoping Sheets*** (10 examples are provided in Appendix C). These sheets list suitability scoring components for a targeted segment, identify potential project features like TSP and lane enforcement approaches, and provide rough sketches of street sections and project cost ranges.

These varied components support a RED Lanes planning process that combines analytical rigor and replicable process through the RED Lanes Toolkit with local planning emphases, professional judgment, and regional collaboration to identify suitable RED Lanes segments and develop effective projects. This combination of elements is shown in Figure ii.

CAMPO developed the RED Lanes Study in coordination with a **Core Technical Team (CTT)** consisting of planning professionals at CAMPO, transit agencies, local member jurisdictions, and NCDOT. The CTT reviewed study products and provided guidance and feedback on the RED Lanes suitability analysis process, the RED Lanes Toolkit, candidate segment identification, and more.

The RED Lanes Toolkit is designed to be updateable such that new or improved data or processing steps can generate updated regional RED Lanes suitability rankings. The toolkit can also be used for scenario planning applications to test project alternatives' impacts on RED Lanes suitability. CAMPO will maintain the suitability analysis process and Red Lanes Toolkit used to generate suitability scores and will collaborate with member jurisdictions on application of the approaches described in this report to provide assistance in identifying and advancing candidate transit priority projects.

Findings of the RED Lanes Study

Key factors considered when evaluating RED Lanes suitability include travel demand, transit operations, highway operations, and local context and design characteristics. The RED Lanes study produced a quantitative, data-rich methodology and implementation toolkit to integrate and analyze each of these factors. The process assigns a RED Lanes suitability score to each roadway segment, and high-scoring segments are identified for potential future study by any of the CAMPO region's agencies responsible for implementing transportation projects.

Figure iii shows the RED Lanes suitability scores for segments throughout the region. As might be expected, the highest scores tend to be those where development densities are highest with a concentration of high scores in the more urbanized portions of the City of Raleigh and the Town of Cary. Higher scoring segments also tend to be aligned with radial commuter corridors connecting urban centers to more distant communities such as Wake Forest to the north and Fuquay-Varina to the south. These results are presented in tabular form in Appendix A and in an interactive **web map**.[1]

Suitability scores are enriched with other factors to provide detailed differentiation among segments and guide project implementation. These additional measures round out the quantitative components of the RED Lanes Evaluation Methodology. The full array of quantitative findings provides meaningful insight but does not constitute a direct prioritization of segments or present definitive thresholds related to funding for RED Lanes planning or implementation. RED Lane implementation will rely on stakeholder judgment, local leadership, and regional coordination informed by the quantitative analysis results generated by the RED Lanes Toolkit. Figure iv shows ten segments with high RED Lanes suitability throughout the region. These were selected from a larger collection of high-scoring segments based on geographical coverage, diversity of roadway design and development contexts, transit and highway operational traits, and peaking of travel demand.

Detailed maps and metrics related to RED Lanes suitability are presented in the ***Existing Conditions Report*** (Report 3).

[1] https://renaissance-planning.carto.com/u/renaissanceplanning/builder/57be1ec7-31ea-4ed8-894b-118f15eb2562/embed

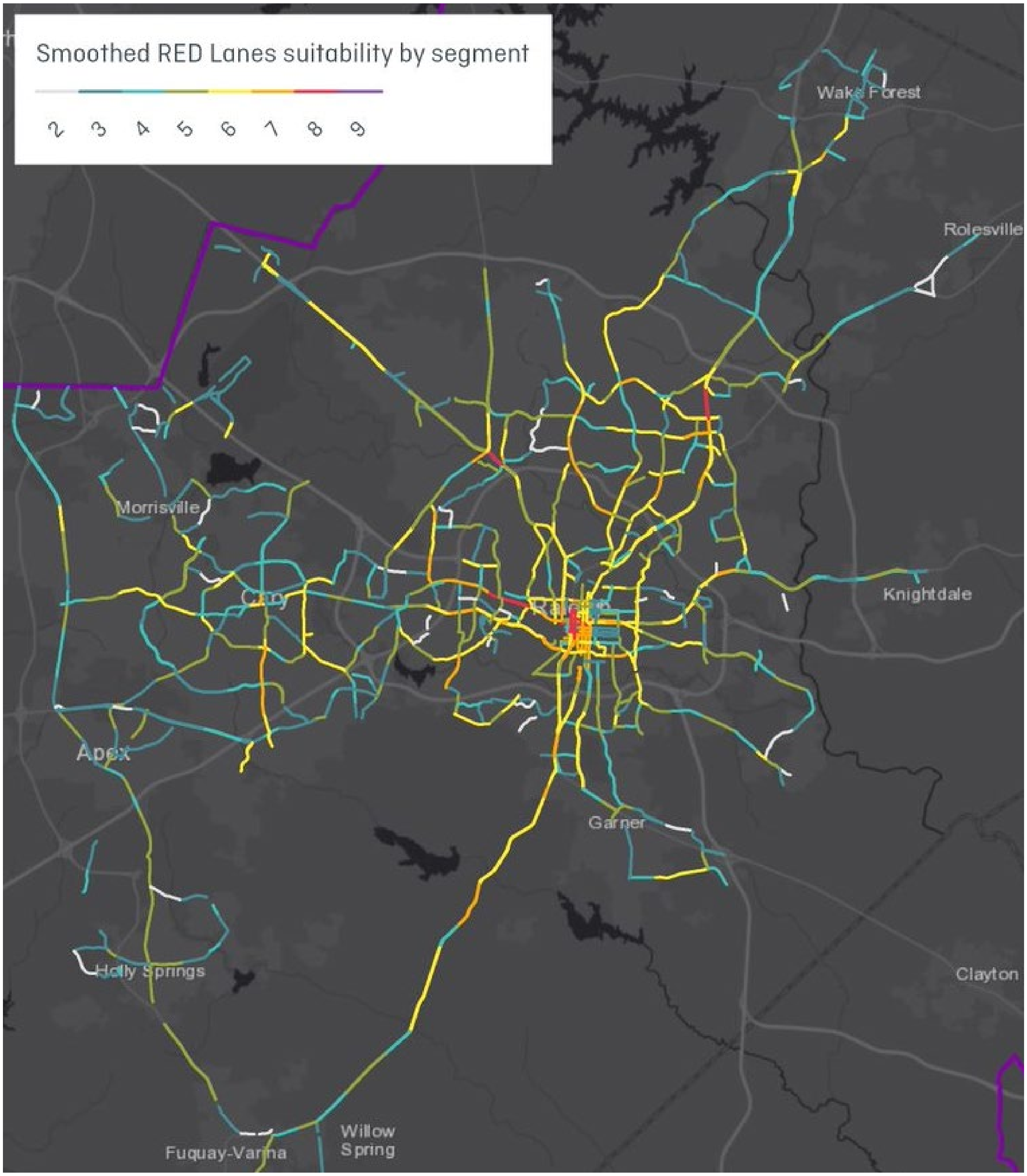

Figure iii RED Lanes Suitability Scores

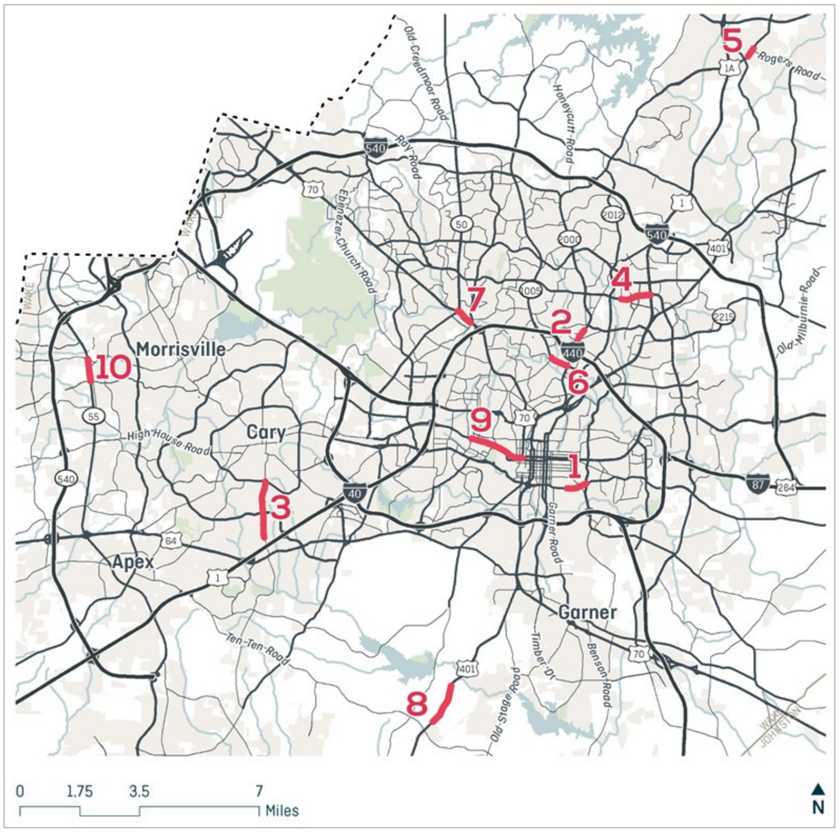

Figure iv Ten RED Lanes Candidate Segments

1. **Martin Luther King Jr. Blvd.** – State St. to Raleigh Blvd.
2. **Wake Forest Rd.** – St. Albans Dr to Colby Dr.
3. **Kildaire Farm Rd.** – Maynard Rd. to Glasgow Rd.
4. **Millbrook Rd.** – Departure Dr. to Capital Blvd.
5. **Main Street** – Capcom Ave. to Selsey Dr.
6. **Six Forks Rd.** – Wake Forest Rd. to Anderson Dr.
7. **Glenwood Ave.** – Creedmoor Rd. to Lead Mine Rd.
8. **Fayetteville Rd.** – Manor Ridge Rd. to Caddy Rd.
9. **Hillsborough St.** – Glenwood Ave to Dan Allen Dr.
10. **NC 55** – Morrisville Pkwy. to Carpenter Fire Station Rd.

Contents of this Report

The RED Lanes Study Final Report provides an overview of the RED Lanes Study, reviews and summarizes the tasks and deliverables completed in the RED Lanes Study. It begins with a brief overview of what RED Lanes are, their role in the CAMPO region's multimodal transportation planning, and operational characteristics and benefits, highlighting how the study can aid in identifying and developing successful RED Lanes projects. It then offers a brief discussion of key considerations in planning for RED Lanes implementation in the CAMPO region, including synergies between existing planning efforts and RED Lanes projects as well as the relationship between BRT and RED Lanes. Next, near-term opportunities for RED Lanes are identified through a review of the RED Lanes evaluation methodology and summarization of its outputs. Project scoping guidance is provided to assist local planning partners in preparing studies for potential RED Lanes projects. Finally, RED Lanes planning next steps and the future of the RED Lanes Toolkit and Evaluation Methodology are discussed.

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Study Overview

What is a RED Lane?

A RED Lane is a transit-priority travel lane with restrictions for other modes. While RED Lanes restrict non-transit users within the lane, they do not necessarily exclude them. In fact, buses typically share RED Lanes with right turning cars, emergency vehicles, and driveway access. The primary objective of RED Lanes is to optimize bus operations in a corridor to maximize transit competitiveness, reliability, and ridership through the dedication of right-of-way (ROW). RED Lanes also aim to minimize disruption to drivers by sharing the dedicated lane space with turning vehicles and emergency services.

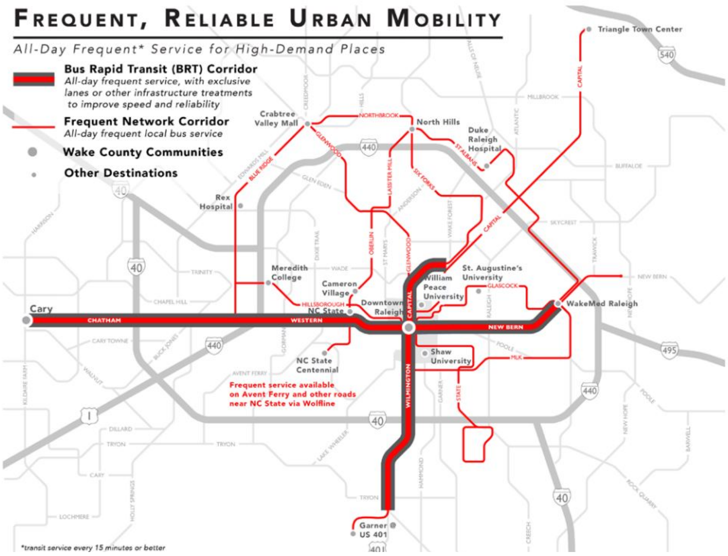
The RED acronym highlights these typical characteristics of the transit priority lanes and reflects the frequent application of red surface treatments to demarcate transit lanes from general use traffic lanes. Although the acronym emphasizes the potential for RED Lanes to share space with other motor vehicles, bicycles are also sometimes allowed in transit lanes and a variety of design options are available for implementation that may exclude some or all shared uses. RED Lanes are sometimes referred to as business access and transit (BAT) lanes or simply transit priority lanes.

Why a RED Lane Study?

The Triangle area is one of the fastest growing regions in the nation with Wake County being home to over 1 million people, with 60 persons a day moving here. The population growth is leading to increased levels of congestion and traffic in our corridors and studies and plans indicate the demographics are further changing. To prepare for these and other challenges, the region is planning and implementing various strategies to improve conditions along major corridors and decrease traffic including, but not limited to, bus rapid transit (BRT), transit priority signaling and commuter rail. RED priority bus lanes in appropriate corridors are being considered to facilitate successful transportation multi-modal use corridors in response to this expected growth. RED Lanes may be a supportive strategy in BRT implementation, setting the stage for eventual BRT implementation in a corridor. These lanes

Bus priority lanes can be implemented in a variety of ways and in a variety of contexts. Other users, like bicycles, taxis, and emergency vehicles can use the lanes. Pavement markings, posted speeds, and parking restrictions vary. (Source: Greater Greater Washington) enable bus routes to be served effectively and efficiently while still allowing cars to travel along major corridors.

RED Lanes are part of a suite of cost-effective strategies available to the Triangle area to efficiently enhance the multimodal transportation system with the aim of increasing multimodal utilization and maintaining or improving travel conditions on major corridors. The recent approval of a half-cent sales tax intended for use on transit improvements in Wake County is an indication of the area's commitment to improving the public transit mobility and accessibility. Additionally, the Regional Transportation Alliance (RTA) with support from GoTriangle and North Carolina Department of Transportation (NCDOT), is funding and coordinating a study to accelerate the creation of a regional Freeway and Street-based Transit (FAST) network that would better connect the entire Triangle area while improving accessibility and opportunity. These and many other efforts aim to identify key intervention points where transportation funds can be utilized efficiently to enhance multimodal capacity and performance, creating the maximum impact on area connectivity with minimal spending.



Various plans throughout the CAMPO region emphasize improved transit mobility, accessibility, and reliability as part of the region's vision for enhanced multimodal transportation. (Source: Wake Transit Plan, 2016)

THE ROLE OF A RED LANE STUDY

The primary focus of this study is on developing a process for evaluating and prioritizing potential investments in RED priority bus lanes. The Capital Area Metropolitan Planning Organization (CAMPO) supports RED Lanes as strategic multimodal investments guided by robust analysis. The reports and toolkit developed as part of the RED Lanes Study build on the previous experiences of other regions, emphasize consistency with regional plans, and offer insight into existing travel conditions and emerging trends. They provide the analytical foundation to identify corridors in which RED Lane implementation will provide maximum impact. The RED Lanes study generated a RED Lanes Evaluation Methodology and the RED Lanes Toolkit for assessing segment-level suitability for RED Lanes throughout the region. The toolkit is available to regional partners for project planning and evaluation applications.

Beyond assessing RED Lanes suitability, the study provides guidance for interpreting suitability scores and supporting detailed metrics to initialize scoping for potential RED Lanes projects. Candidate Corridor Scoping Sheets have been developed for ten high-suitability corridors (shown in Figure 1) as examples for framing detailed RED Lanes studies in various contexts. The scoping sheets also include ballpark costs for prospective RED Lanes. Local agencies responsible for transportation planning are encouraged to avail themselves of the RED Lanes Toolkit to identify RED Lanes candidates, initialize appropriately scoped planning studies, and understand the general expected magnitude of investment required.

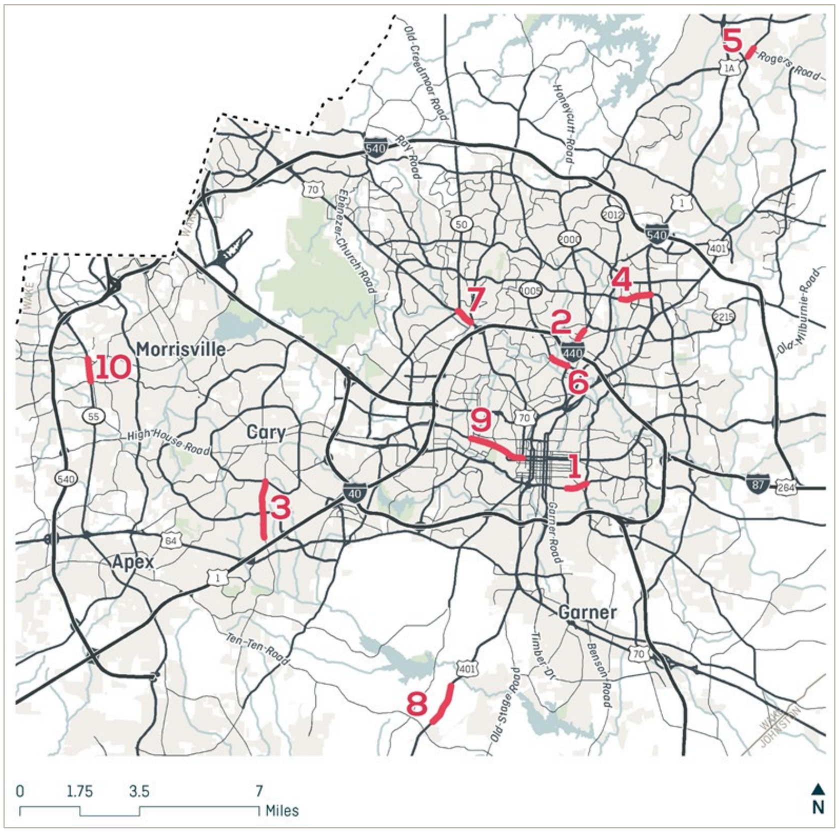


Figure 5 Ten RED Lanes Candidate Corridors

11. **Martin Luther King Jr. Blvd.** – State St. to Raleigh Blvd.
12. **Wake Forest Rd.** – St. Albans Dr to Colby Dr.
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Finally, the RED Lanes evaluation methodology is built on a review of industry literature and case studies as well as multimodal planning priorities expressed in local and regional plans. The RED Lanes Study confirms the consistency of RED Lanes and related transit priority treatments with existing and ongoing plans and provides a summary of best practices to guide RED Lanes planning and implementation.

All products of the RED Lanes Study were reviewed by a Core Technical Team (CTT) consisting of planning professionals at CAMPO, transit agencies, local member jurisdictions, and NCDOT. The CTT provided direction at key stages of the study and feedback that shaped and refined the documents and tools produced by the study.

Suitability Analysis Results

Most road segments with high RED Lane suitability scores are located within the urban heart of the CAMPO region (inside the I-440 loop). However, there are several other highly rated segments located on sections of Glenwood Avenue (near Crabtree Mall), Hillsborough Street (near the North Carolina State Fairgrounds), and Capital Boulevard (near Triangle Town Center). Segments in the medium-to-high ranges of RED Lanes suitability scores are located throughout the region. Many are concentrated in North Raleigh, with more sporadic representation in Cary, Morrisville, Wake Forest, and southern Wake County.

Table 1 lists the top-ranking corridors for RED Lanes suitability in the CAMPO region. Complete suitability results can be explored in Appendix A or in the interactive web map[2], which also allows features to be filtered based on Detailed Differentiator and/or Implementation Guidance metrics (see Elements of RED Lanes Suitability below).

Table 1 Segments with High RED Lanes Suitability in the CAMPO Region

Route	From	To	Suitability
Glenwood Ave	Creedmoor Rd	Blue Ridge Rd	9
Blount St	E Morgan St	E Davie St	8
Capital Blvd	Sumner Blvd	Spring Forest Rd	8
Dawson St	W Lane St	W Davie St	8
Edenton St	N Person St	N McDowell St	8
Founders Dr	Current Dr	Dan Allen Dr	8
Glenwood Ave	Blue Ridge Rd / Lead Mine Rd	Creedmoor Rd	8
Hillsborough St	Henderson St	Gardner St	8
Hillsborough St	Pullen Rd	Gardner St	8
McDowell St	W Cabarrus St	W Johnson St	8
Martin St	Fayetteville St	S West St	8
Morgan St	Glenwood Ave	S Blount St	8
Salisbury St	W Lane St / E Lane St	W Davie St	8
Western Blvd	Clanton St / Whitmore Dr	Varsity Dr	8

Study Accomplishments

In addition to generating RED Lanes suitability scores for roadway segments throughout the CAMPO region, the RED Lanes Study consists of several key products to guide and facilitate RED Lanes planning and implementation in the region. Key study accomplishments are listed below, with related study products highlighted.

- **RED Lanes Toolkit:** The Red Lanes Toolkit contains the analytic databases and processes used to generate suitability scores in a package that produces consistent, replicable results. The toolkit implements the RED Lanes Evaluation Methodology, which provides a uniform methodology for jurisdictions to tailor and select the most suitable corridors for RED Lanes to prioritize in their area. The toolkit facilitates testing of alternative values for weighting the importance of different input metrics, conducting scenario planning for transportation or land use planning purposes, and replicating the prioritization process on a regular basis as regional conditions evolve over time. It lays the groundwork for incorporating RED Lanes analysis into ongoing and future studies and is supported by the *RED Lanes Toolkit User Guide*.
- **Candidate Corridor Scoping Guide:** This guide was developed to provide context and information regarding the creation of RED Lane Candidate Corridor Scoping Sheets. It includes background on the scoring process and interpretation guidance, a menu of cost considerations for key RED Lanes elements, and example typical sections with RED Lanes visualized. RED Lanes planning requires an understanding of the suitability of a corridor for a RED Lanes project, but also a clear understanding of related costs of

[2] https://renaissance-planning.carto.com/u/renaissanceplanning/builder/57be1ec7-31ea-4ed8-894b-118f15eb2562/embed

such projects, such as lane striping, enforcement costs, and transit signal systems. Special attention should also be paid to street design elements to ensure that RED Lanes implementation enhances the corridor of interest. The scoping sheet menu is available in this document as Appendix B.

- **RED Lane Candidate Corridor Scoping Sheets:** RED Lanes Scoping Sheets were developed for ten high-scoring segments across the region. The information on these sheets is intended to help potential project sponsors understand the corridor suitability dimensions and range of treatments that might warrant further study. These sheets present suitability criteria and appropriate potential design, operational, and enforcement elements for ten candidate RED Lane corridors. These are attached as Appendix C.
- **RED Lanes Literature and Research Review:** The prioritization approach was informed by lessons learned from a robust review of literature on RED Lanes implementation nationwide and the state of the practice in developing prioritization tools and approaches. The *RED Lanes Fundamentals Report* documents the literature review findings and case studies. Within the report, there are two-page summaries providing overviews of key RED Lanes topics that are also available as independent handouts:
    - What is a RED Lane?
    - Design Features of RED Lanes
    - Bus Operations and Service on RED Lanes
    - RED Lanes and BRT
    - Best Planning Practices for RED Lanes
    - Cost Considerations for RED Lanes

Planning for RED Lanes in the Capital Region

Characteristics and Design Components of RED Lanes

The primary objective of RED Lanes is to optimize bus operations in a corridor to maximize transit competitiveness, reliability, and ridership through the dedication of right-of-way. RED Lanes also aim to minimize disruption to drivers by sharing the dedicated lane space with turning vehicles and emergency services. They are typically applied in situations where there is a desire or need to reduce delays associated with congestion, implement rapid transit improvements along a corridor, or in cases where policy goals seek to enhance the attractiveness of transit relative to other modes.

RED Lanes can be created through converting an existing traffic lane, eliminating parking, widening a roadway, or utilizing existing unused space in a median. Other non-transit vehicles and users are often allowed in RED Lanes. Non-transit users are typically allowed in RED Lanes when transit volumes (ridership and/or service frequencies) are low enough that their presence will not unduly inhibit travel time savings or reliability benefits to transit vehicles or in cases where shared use of the lane will help reduce implementation costs or achieve other policy goals. Emergency vehicles are always permitted to use RED Lanes.

There are several different types of RED Lanes, including numerous design alternatives to suit corridor-specific conditions and policy objectives. They can be located curbside, offset from the curb (adjacent to on-street parking), or in a variety of other street configurations that meet special situations or needs. The length of a transit lane can vary. In some cases, a RED Lane may run along an entire corridor or bus route. However, it may also be desirable to implement a short RED Lane, such as a queue bypass, which allows a transit vehicle to bypass a specific bottleneck. RED Lanes can also be targeted to specific sections of a corridor, where transit vehicles frequently are delayed by congestion.

Intersection designs for RED Lanes present additional options. RED Lanes can continue through intersections or be dissolved at an intersection approach to accommodate the operational and maneuvering needs of transit vehicles and/or other users, while lane placement varies based on routing and facility attributes. Signal phasing and timing at intersections may also need to be modified. Transit signal priority (TSP) can enhance the effectiveness of RED Lanes by minimizing transit vehicle delays at intersections.

Numerous studies have found that – used in conjunction with traditional signage and lane markings – red surface treatments are effective at reducing RED Lane violations by restricted users. While it is important to consider that special permission may be needed from regional transportation partners (such as NCDOT and local jurisdictions) before red surface treatments are implemented, numerous successful case studies and recommendations exist from professional organizations, making this application process feasible for most communities. However, red surface treatments are not necessary for effective RED Lane implementation, and there are cases in which they are not an appropriate component, such as when RED Lanes restrictions only apply on a part-time basis .

RED Lanes are most effective in corridors with high-frequency and high-volume transit routes. Traffic volumes and delay in the corridor, density and diversity of adjacent land uses, urban design characteristics, and policy objectives are also important considerations in planning for RED Lanes. RED Lanes offer a relatively low-cost solution to enhancing transit service and can serve as a pre-cursor to BRT.

Existing Planning Efforts

In considering the application of transit priority lanes in the CAMPO region, it is also important to understand their relationship to existing and ongoing plans and studies in the region. While the RED Lanes evaluation/prioritization process identified corridors with the highest suitability for RED Lane implementation, the specific design choices and components of each facility will be highly context-specific and require a thorough understanding of existing planning efforts.

The *Key Plans in the CAMPO Region Report* generated as part of the RED Lanes study details core plans and studies from throughout the region and their relevance to planning for transit priority lanes. It highlights the major themes and emphases of recent planning efforts that informed the development of the RED Lanes evaluation process. Collectively, the plans reviewed reveal several key emphasis areas of regional planning that can be organized into five primary topic areas:

1. **Create a multimodal transportation network:** Many plans emphasize complete streets design principals, creating facilities that are safe and comfortable for all users. Numerous plans, especially those with a regional scope, emphasize developing viable alternatives to auto travel and multi-modal strategies for congestion relief.
2. **Provide high quality transit on key corridors:** Several plans – most notably the *Wake Transit Plan* – call for significant augmentation to the regional bus network. This includes the designation of several BRT corridors, some of which are the subject of ongoing studies and are in development.
3. **Reduce congestion on all roads, especially those providing key regional connections:** Although many plans emphasize increasing multi-modal options, they also acknowledge the automobile as the dominant mode for regional mobility and the need to continue to invest in highways to meet the region's travel needs while diversifying options over time.
4. **Improve safety and mobility for all modes:** All plans emphasize safety, aiming to reduce incidents and minimize risk to all travelers. In many cases, safety is addressed through operational and design enhancements to facilities or intersections.
5. **Integration of land use and transportation plans:** Increasingly, planning documents are directly addressing the connection between land use or land development patterns and transportation system design and performance. Many plans in the CAMPO region acknowledge this connection and call for context-sensitive strategies that accommodate/prioritize modes and movements appropriately based on built environment characteristics.

Examples of existing plans that focus on or emphasize transit mobility, quality and coverage of service, and/or improved operations include the 2045 Metropolitan Transportation Plan (MTP), Wake Transit Plan (2016), the Wake Bus Plan (2019), CAMPO's Commuter Corridors Study (2019), and numerous subarea and corridor studies. Additionally, the RTA with support from GoTriangle and NCDOT, is funding and coordinating a study to accelerate the creation of a regional FAST network that would better connect the entire Triangle area while improving accessibility and opportunity.

RED Lanes and BRT

BRT is defined by the Federal Transit Administration (FTA) as "a high-quality bus-based transit system that delivers fast and efficient service that may include dedicated lanes, busways, traffic signal priority, off-board fare collection, elevated platforms and enhanced stations." Transit priority lanes, including RED Lanes, can be integrated into BRT projects where appropriate, or may stand alone as suitable treatments fully independent of BRT considerations.

BRT projects can be defined as either Fixed-Guideway BRT or Corridor Based BRT. Fixed-Guideway BRT projects must include a dedicated lane for transit vehicles during peak traffic periods for at least 50% of the BRT corridor length. Both Fixed-Guideway and Corridor Based BRT projects often include a variety of transit priority design treatments that vary from segment to segment and are customized to the needs and constraints of each segment.

There are several notable differences and commonalities among BRT, RED Lanes, and other transit priority lanes. Based on the RED acronym (Right turns, Emergency Vehicles, and Driveway access), certain designs with bus priority in the median, along the left side of a one-way street, or in a contraflow treatment are not applicable for RED Lanes but may be applicable for BRT and for other transit priority lanes. Additionally, in North Carolina (and most jurisdictions nationwide) emergency vehicles are allowed access into bus priority treatment areas by law. Alternatively, BRT systems (both Fixed-Guideway and Corridor Based) are defined in large part by service characteristics including service frequency, TSP systems, and defined stations that including passenger amenities beyond those associated with typical bus stops.

In summary, project characteristics that would be required for federal funding of BRT projects are not as formally defined in RED Lanes or other transit priority lanes. However, all three of these bus priority treatment options seek to improve transit service performance in corridors where multimodal demand warrants their consideration. The consideration of appropriate transit priority lane treatments within the CAMPO region therefore benefits from an appreciation of the design elements and lessons learned from case studies across all three treatments.

Given these similarities, RED Lanes may be implemented as a stepping stone toward BRT implementation in some corridors, enhancing transit operations and mobility, reliability, and visibility in the corridor. Accompanied by transit-supportive land use policies, the corridor may evolve into a multimodal environment in which ridership trends and incremental development costs are competitive for federal funding grants to implement full-fledged BRT.

Where Are the Near-Term Opportunities for RED Lanes?

Elements of RED Lanes Suitability

For all roadways in the CAMPO region, a value was assigned that reflects its suitability for RED Lanes. This RED Lanes suitability score attempts to account for those road and location characteristics that are associated with effective RED Lanes implementation. The major dimensions of RED Lanes suitability were identified and defined based on a review of RED Lanes literature, analysis of existing conditions and forecasted trends in the CAMPO region, and input from the CTT. Suitability dimensions identified include:

1. Travel demand
2. Transit operations
3. Highway operations
4. Context and design

Each dimension was assessed with reference to a collection of specific measures. Dimensional scores were then combined to generate suitability scores for localized road segments. This hierarchical grouping of metrics by dimensions is shown in Figure 2. Table 2 lists the metrics used to evaluate each dimension and the logical relationship of each to RED Lanes evaluation. Suitability scores generated range from 0 (no suitability) to 10 (maximum theoretical suitability). The highest scoring segments in the CAMPO region attained a score of 9.

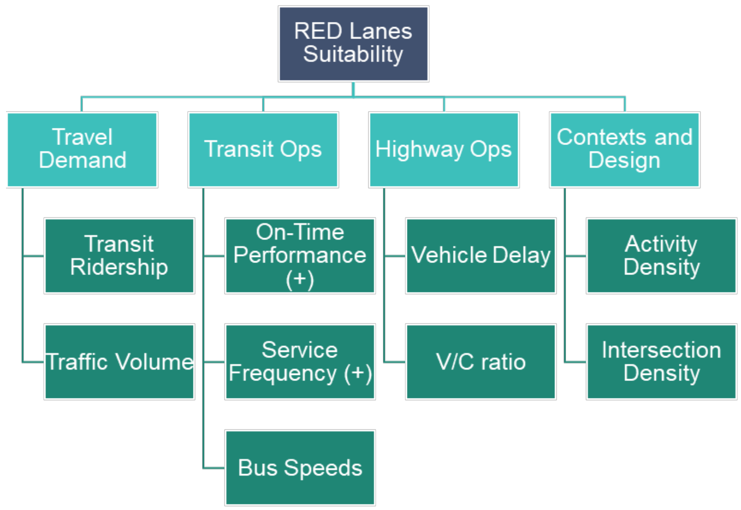

Figure 6 RED Lanes Suitability Key Dimensions and Metrics

Table 2 Key Dimensions of RED Lanes Suitability and Supporting Metrics

Dimension	Metric	Relationship to RED Lanes
Travel demand	Transit ridership	RED Lanes offer potential benefit to more individuals along transit-heavy corridors
	Traffic volume	RED Lanes offer potential benefit to more individuals along highly traveled corridors
Transit operations	On time performance (OTP)	RED Lanes can improve schedule adherence along corridors that typically struggle with OTP
	Service frequency	RED Lanes are more justifiable along corridors where transit service is frequent
Highway operations	Bus speed	RED Lanes can improve bus speed along low-speed transit corridors
	Vehicle delay	RED Lanes can improve consistency of travel times for transit vehicles in congested areas
	Volume-to-capacity ratio	RED Lanes can improve congestion issues on corridors with high (but not extreme) congestion
Context and design	Activity density	RED Lanes are more appropriate in “transit-supportive” contexts, for which activity density (jobs per acre plus housing units per acre) and intersection density are proxy measures
	Intersection density	

Suitability scores provide insight into the appropriateness of RED Lanes based on transportation system performance and contexts. Further detailed differentiation among candidate segments was provided by assessing general feasibility of implementation as well as the relationship of the segment to Communities of Concern. These Detailed Differentiator analyses are outlined in Figure 3.

The feasibility assessment considered available right-of-way by referencing data on existing street widths, assuming the addition of an 11-foot RED Lane in each travel direction, and the number of proximate buildings potentially impacted by widening. It also considered the existing number of lanes for facilities, since RED Lanes can sometimes be implemented through repurposing existing lanes, and highlighted facilities where widenings are planned. This provides a coarse understanding of where RED Lanes could be readily implemented. Communities of Concern refer to transportation-disadvantaged populations, stratified by age, race, ethnicity, income, linguistic isolation, and vehicle ownership. RED Lanes serving areas where these communities of concern overlap can be expected to provide accessibility and mobility benefits that support local and regional goals related to equity in transportation. Together, these Detailed Differentiator analyses provided opportunities for local context and planning goals to impact final suitability scores and weighting.

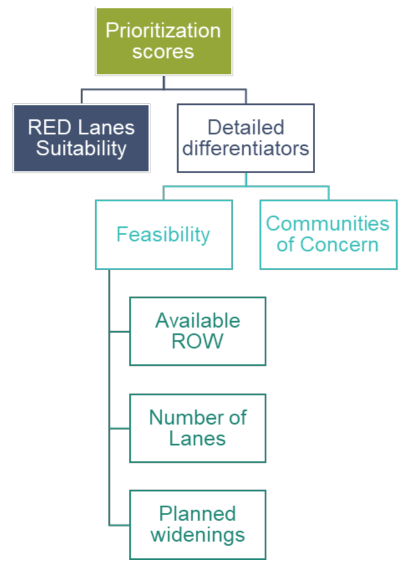

Figure 7 Detailed Differentiators

Prioritization and Detailed Differentiators ground the RED Lane suitability scoring process in the reality of the local implementation landscape. A road may be ideally suited to RED Lanes implementation based on suitability scores but have limited impact on Communities of Concern. The RED Lanes Toolkit generates both raw suitability scores and Detailed Differentiator scores for each road segment to provide holistic insight into performance and policy contexts for a potential RED Lane project.

The development of candidate corridors for further study includes consideration of implementation variables that help define the practicality of different investment levels in RED Lanes treatments for any given location. The differentiation between suitability and practicality can be summarized as follows:

- Suitability describes the relative need for and value of some sort of RED Lanes priority treatment based on travel demand, transit and roadway operations, context and design; but it is agnostic regarding the most cost-effective type of treatment.
- Practicality summarizes some of the tradeoffs to be addressed during further study; perhaps best exemplified by decisions regarding whether repurposing of existing pavement through narrower lanes, parking removal, or reduction in the number of travel lanes is an effective treatment, or whether additional pavement needs to be added to both achieve transit priority while balancing the needs of all other modes.

Figure 4 shows the types of Implementation Guidance described for candidate corridors.

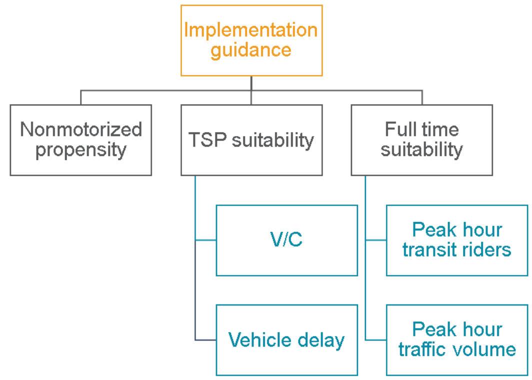

Figure 8 Implementation Guidance

Nonmotorized propensity considers the degree to which pedestrian and bicycle travel are integral considerations in defining transit priority and allocating space within the right-of-way. Consideration of bicyclists and pedestrians in a detailed RED Lane implementation study may be guided by the expected presence of non-motorized users in the corridor as well as plans and policies that emphasize non-motorized travel in the corridor or surrounding area.

Transit signal priority (TSP) suitability describes the appropriateness of operational transit priority treatments alongside physical space priority in a potential RED Lane project. This is a coarse assessment since TSP is not the focus of the current study.

Full time suitability describes the degree to which transit priority treatments would be desirable for all-day treatments as contrasted with part-time use, such as a curb lane that might be best used for transit vehicles during peak commuter periods but available for other uses such as parking or loading at other times of day. Full time RED Lanes are best suited in corridors where travel demand and/or high-frequency transit services operate throughout the day rather than in peak commuting periods.

Table 3 lists the key dimensions and supporting metrics of the Detailed Differentiator and Implementation Guidance analyses, along with their logical relationship to RED Lanes suitability and practicality.

Table 3 Detailed Differentiator and Implementation Guidance Dimensions and Metrics

Dimension	Metric	Relationship to RED Lanes
Communities of concern	Communities of concern	RED Lanes have a more positive impact if they provide mobility benefits to disadvantaged populations
Feasibility	Available ROW	RED Lanes are less feasible on more constrained segments where they will impact more buildings
	Number of lanes Planned widenings	RED Lanes are more feasible where an existing lane can be used RED Lanes are more feasible on segments expected to be widened
Non-motorized propensity	Non-motorized propensity	RED Lanes with high non-motorized propensity should directly account for non-motorized users in facility design.
TSP suitability (TSP may be an appropriate operational enhancement accompanying a RED Lane project, but is not the focus of this study)	V/C	TSP is most appropriate in areas with moderate V/C; with too low V/C TSP is unnecessary, and with too high V/C transit vehicles cannot take advantage of TSP
	Vehicle delay	TSP is most appropriate in areas with moderate delay; with too little delay TSP is unnecessary, and with too much delay transit vehicles cannot take advantage of TSP
	Transit OTP	TSP is more appropriate in areas with schedule adherence issues
Full time suitability	Peak-hour transit riders	Full-time suitability is less appropriate when a larger share of riders occur during the peak period
	Peak-hour traffic volume	Full-time suitability is less appropriate when a larger share of volume during the peak period

Data and Methods

Data sources for the RED Lanes evaluation process were identified with reference to the *RED Lanes Fundamentals Report* and the *Existing Conditions Report*, both generated in the early stages of the RED Lanes Study. The *RED Lanes Fundamentals Report* cited the following as key considerations in RED Lanes planning and implementation:

1. Transit vehicle volume
2. Person throughput by all modes
3. Volume-to-capacity (V/C) ratio and highway level of service
4. Reliability, travel time variability, delay
5. Safety
6. Available right of way and physical/spatial constraints

Apart from safety, all above considerations were analyzed in the *Existing Conditions Report.* While safety remains a key consideration in RED Lanes implementation, it is most appropriately addressed on a project-by-project basis to shape the design and operating conditions of each facility. The *Existing Conditions Report* identified regionally available data sources, analysis methods, and specific measurements associated with each consideration. The metrics generated were organized into the analysis trees for RED Lanes Suitability (Figure 2), Detailed Differentiators (Figure 3), or Implementation Guidance (Figure 4) shown above and then passed to the RED Lanes Toolkit.

For all metrics, spatial analysis and GIS software were used to generate raster datasets[3] reflecting values like transit ridership, service frequency, vehicle delay, etc. This approach allows the RED Lanes Toolkit to assess which locations have a confluence of RED Lanes suitability indicators from a variety of data sources, such as the Triangle Regional Model, regional transit operators, the Wake Bus Plan, etc. In most cases, a 200-foot buffer was used to calculate a statistic for each cell, such as the total transit ridership or the worst-case volume-to-capacity ratio in the area. In some cases, the value of the raster cell simply reflects the value of an overlapping area, such as the number of Communities of Concern in the block group where the cell is located.

After values were calculated and recorded in raster cells, each metric's resulting values were grouped into scores ranging from 1 to 10, where 1 indicates very low suitability and 10 indicates maximum suitability. In this scoring system, zeros indicate missing data, which correspond to irrelevant locations (i.e., cells that are more than 200-feet away from a road). In the RED Lanes Toolkit, these value groupings are specified by the analysts, relying on data visualization, professional experience, and regional expertise. The groupings used to evaluate suitability for the RED Lanes Study were vetted and refined through coordination with the CTT.

A rundown of data sources and measurement methods for the RED Lanes suitability analysis is provided in Table 4, while Table 5 presents similar information for the Detailed Differentiator and Implementation Guidance metrics. Details on the calculations, data, and rationale behind all metrics are provided in the *RED Lanes Evaluation Methodology Report*.

[3] Rasters are matrices of equally sized grid cells arranged in rows and columns. Each cell contains a value representing information, such as the density of activity in the block group where the cell is located or the total transit ridership along routes within 200 feet of the cell's center.

Table 4 Data Sources and Measurement Methods for RED Lanes Suitability Metrics

Dimension	Metric	Data Source	Measurement
Travel demand	Transit ridership	TRM 2045 route-level transit ridership forecasts	Total ridership on all routes in a given area
	Traffic volume	TRM 2045 traffic forecast	Total traffic volume, excluding limited access highways
Transit operations	On time performance (OTP)	Route-level OTP from transit agencies; segments and intersections of concern from NCSU	Average route-level OTP in area (highlight segments and intersections that consistently pose delays for NCSU Wolfline)
	Service frequency	Wake bus plan routes and headways; MTP routes and headways (for horizon years 2018, 2024, 2027, 2045)	Weighted average of cumulative buses per hour during peak period for each horizon year (2018: 40%; 2024: 30%; 2027: 20%; 2045: 10%)
	Bus speed	TRM 2045 highway network bus speed forecasts	Average bus speed
Highway operations	Vehicle delay	TRM 2045 loaded highway network	Minimum congested-to-free-flow speed ratio
	V/C ratio	TRM 2045 loaded highway network	Take the maximum V/C ratio
Context and design	Activity density	TRM 2013 zonal data	Activity unit density (jobs + households per acre)
	Intersection density	EPA Smart Location Database (2010)	Inherit intersection density (variable D3b)

Table 5 Data Sources and Measurement Methods for Detailed Differentiator and Implementation Guidance Metrics

Dimension	Metric	Source	Measurement
Communities of concern	Number of communities of concern served	CAMPO communities of concern polygons	Number of communities of concern in block group
Feasibility	Available ROW	NC route characteristics; Microsoft building footprints polygons[4]	Estimated number of buildings impacted per mile if roadway is widened by 11' in each travel direction.
	Number of lanes	TRM 2013 highway network	Number of lanes in each travel direction
	Planned widenings	TRM 2045 highway network	Number of new lanes to be added
Non-motorized propensity	Non-motorized propensity	University of Minnesota Accessibility Observatory 2014 Walk Access Scores	Number of jobs accessible by walking (block scale)
TSP suitability	V/C	TRM 2045 highway network	Maximum V/C ratio
	Vehicle delay	TRM 2045 highway network	Minimum congested-to-free-flow speed ratio
	Transit OTP	OTP overlay from the suitability analysis	See transit OTP scores created for the suitability analysis
Full time suitability	Peak-hour transit riders	TRM 2045 transit ridership forecasts	Average ratio of peak-hour (AM+ PM) transit ridership to daily ridership
	Peak-hour traffic volume	TRM 2045 traffic volume forecasts	Average ratio of peak-hour (AM+ PM) traffic volume to daily volume

[4] https://github.com/Microsoft/USBuildingFootprints

Summarization and Reporting of Scores

For each analysis tree (Suitability, Detailed Differentiators, Implementation Guidance), weighted overlays were used to combine various metrics within each dimension and (for the suitability analysis) to combine dimensional scores into an overall suitability score. The weights used in these combination steps were developed in coordination with the CTT and vetted through the CAMPO Technical Coordinating Committee.

Table 6 and Table 7 show the weighting schemes applied within each dimension for the suitability analysis and the Detailed Differentiator and Implementation Guidance analyses, respectively. Table 6 also shows the weights used when combining dimensional scores into the total suitability score.

Table 6 Metric and Dimensional Weights in RED Lanes Suitability Analysis

Dimension	Metric	Metric Weight (within dimension)	Dimension Weight (total suitability)
Travel demand	Transit ridership	60%	30%
	Traffic volume	40%	
Transit operations	On time performance (OTP)	25%	25%
	Service frequency	50%	
	Bus speed	25%	
Highway operations	Vehicle delay	50%	30%
	V/C ratio	50%	
Context and design	Activity density	50%	15%
	Intersection density	50%	

Table 7 Metric and Dimensional Weights in Detailed Differentiator and Implementation Guidance Analyses

Dimension	Metric	Metric weight (within dimension)
Communities of concern	Communities of concern	100%
Feasibility	Available ROW	33%
	Number of lanes	33%
	Planned widenings	33%
Non-motorized propensity	Non-motorized propensity	100%
TSP suitability	V/C	40%
	Vehicle delay	25%
	Transit OTP	35%
Full time suitability	Peak-hour transit riders	70%
	Peak-hour traffic volume	30%

The final steps in suitability reporting involved masking out irrelevant segments and performing a smoothing analysis to translate raster suitability scores to linear features with logical segmentation limits. The masking process involved the removal of segments with no existing or planned transit as well as limited access highways (bus-on-shoulder use for limited access highways without at-grade intersections or driveways are excluded from the prioritization process). Thus, RED Lane suitability scores are reported only for arterial roadway segments where RED Lanes are applicable. Segments for which there are existing studies for fixed-guideway transit improvements were identified but not masked in the final score reporting to provide added context to the results.

The masked suitability scores were then smoothed from the raster dataset into linear features with logical segmentation limits. The smoothing process utilized the NCDOT Route Characteristics line features, showing all roads in the state. These lines were intersected with non-zero suitability raster cells to highlight street features with potential RED Lanes suitability. Next, a series of feature and attribute selection criteria were applied to select only those street features that have RED Lanes suitability for a significant length (a quarter mile or longer). Then, average suitability scores were obtained for the remaining segments, and intersection data were used to ensure that locations where suitability averages shifted corresponded to logical termini based on the street network. The smoothing process was automated in a script (using the R programming language), which is included as part of the RED Lanes Toolkit. For additional details, see the *RED Lanes Evaluation Methodology Report*.

Figure 5 shows the RED Lanes suitability scores that result from the scoring and summarization processes described above. As might be expected, the highest scores tend to be those where development densities are highest with a concentration of high scores in the more urbanized portions of the City of Raleigh and the Town of Cary. Higher scoring segments also tend to be aligned with radial commuter corridors connecting urban centers to more distant communities such as Wake Forest to the north and Fuquay-Varina to the south. The level of variability within given corridors reflects several influences, notably the presence of natural and manmade barriers such as rivers, railroads, and freeways that constrain demand at all modes to a few crossing points, as well as the confluence of multiple bus routes that either share certain roadway segments or cross at intersections, raising the relative value of transit service at those points.

For each segment with suitability data, Detailed Differentiator and Implementation Guidance metrics have been summarized. Each of these metrics was summarized into a low, medium, or high rating. Together, the suitability scores with enrichment metrics provide a quantitative assessment of where RED Lanes are likely to be most effective.

These quantitative findings provide meaningful insight, but they do not constitute a direct prioritization of segments or present definitive thresholds related to funding for RED Lanes planning or implementation. The transition from fully quantitative analysis results to recommended candidate corridors for RED Lanes implementation involves stakeholder judgment, local leadership, and regional coordination. Exemplifying this dynamic, the candidate corridors displayed and listed in Figure 1 (see page 3) are not the top-scoring corridors in terms of suitability. Rather, they are among the most practical corridors for further study, having medium or high suitability scores and representing diverse conditions in which RED Lanes can provide transit mobility benefits. A RED Lanes Corridor Scoping Sheet is provided for each corridor in Appendix C.

The next section describes the interpretation of the outputs of the RED Lanes Toolkit for project scoping and development.

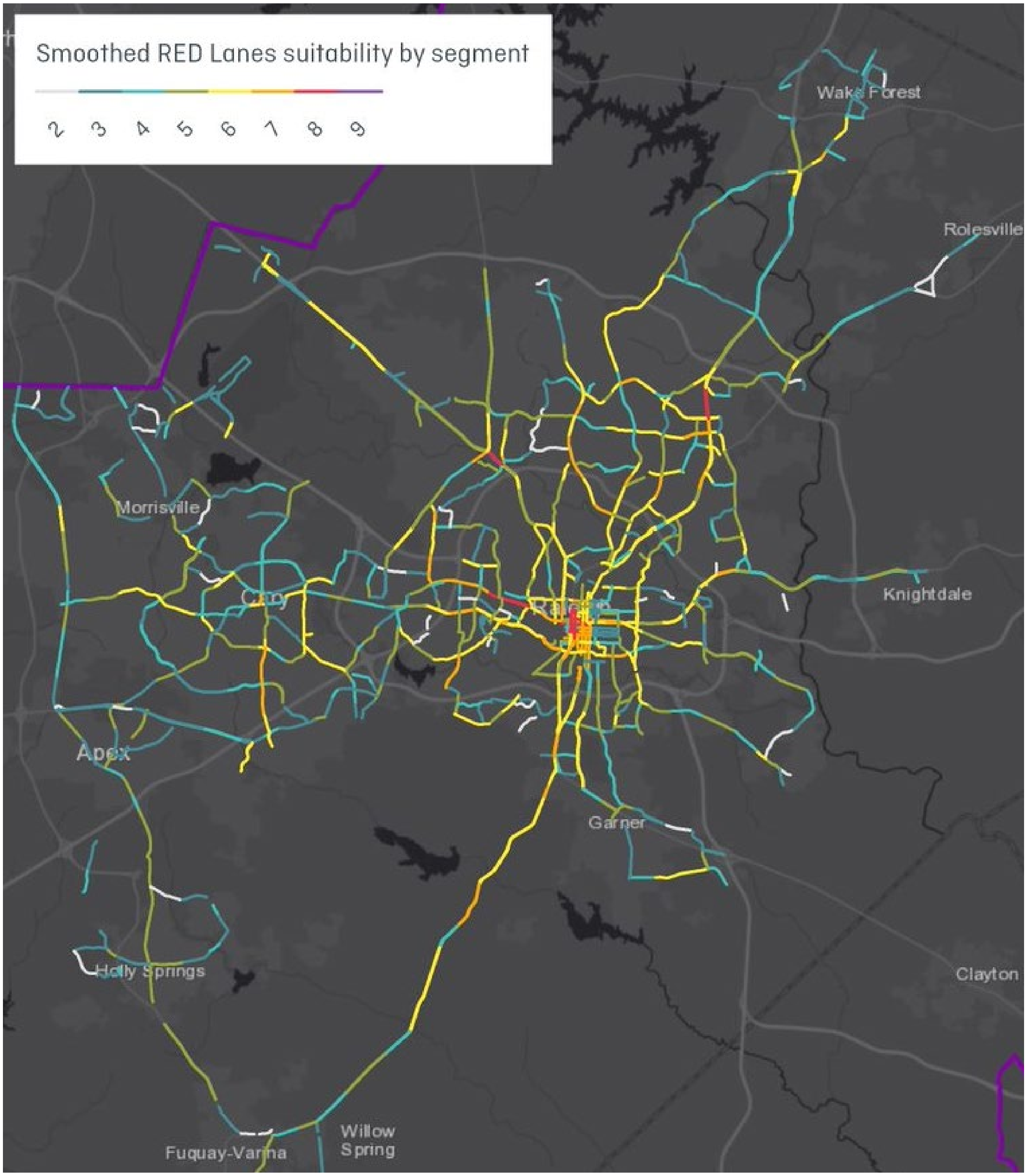

Figure 9 RED Lanes Suitability Scores

Scoping and Developing RED Lanes Projects

Local Involvement

CAMPO has led the development of the RED Lanes suitability analysis process and will maintain both the RED Lanes Toolkit and updates to the toolkit databases to provide new suitability scores for candidate corridors on a regular basis to inform discussions on regional transit priorities by decision makers. CAMPO also expects the suitability evaluation process and toolkit to serve as a resource for member jurisdictions and transportation agencies at all levels of government to assist their processes for identifying and prioritizing transit improvements.

Toolkit Uses

The RED Lanes Toolkit is intentionally flexible, designed to support a variety of local applications related to RED Lane project development. The toolkit can be used to:

- Re-weight metric or dimensional scores to reflect local priorities
- Conduct scenario analysis (e.g., alternative transit routes or service frequencies)
- Test alternative policies (e.g., changes to land use forecasts)

As CAMPO moves forward with transit project development, it will consider local priorities, toolkit outputs and information derived from this study to inform regional funding priorities for RED Lanes. CAMPO may also use the toolkit to help inform local priorities and choices as compared to the modeling output and other data and processes used for project selection.

Scoping Sheet Menu

The RED Lanes Toolkit evaluates the suitability of a given corridor or segment for RED Lanes and reports Implementation Guidance measures that highlight potential design, operations, and enforcement elements for candidate corridors. The toolkit outputs help identify opportunities for strategic investment in RED Lanes as low-cost stand-alone projects or additions to ongoing projects. RED Lanes are part of a broad regional strategy to enhance transit mobility and visibility throughout the CAMPO region to maintain a safe, convenient, and efficient multimodal system.

As a supporting document related to the interpretation of toolkit outputs, the RED Lanes Study includes a Scoping Sheet Menu. This guide is intended to aid in generating Candidate Corridor Scoping Sheets based on RED Lanes Toolkit outputs. The scoping sheets, in turn, frame appropriate planning emphases and provide rough cost estimates for RED Lanes implementation through brief interpretation of toolkit outputs. The Scoping Sheet Menu is available as Appendix B in this document; example scoping sheets for 10 RED Lanes candidate corridors (those identified in Figure 1) are provided as Appendix C.

Table 8 reproduces the Scoping Sheet Menu's high-level guidance for interpretation of several Implementation Guidance Metrics, while Table 9 outlines typical costs for various RED Lanes elements. The Scoping Sheet Menu offers guidance regarding which elements are appropriate based on Detailed Differentiator and Implementation Guidance outputs.

Detailed design and traffic studies are required to assess the impacts of RED Lanes on traffic flow, street design, and other related elements. The estimates developed for project scoping sheets only include improvements between the curbs and do not include right-of-way acquisition, shifting utilities or any changes to the streetscape outside the curbs. While calculating the costs of the corridor, a 50% contingency is recommended to be added to this cost which will include Design costs, oversight and other contingencies.

Table 8 RED Lanes Elements to Consider Based on Implementation Guidance

Code	Cost Element	Candidate Corridor Attributes
LANE TYPE		
L1	Standard Bus Lane – White Pavement Striping	**Full-time suitability** is Low or Medium
L2	Red Paint Bus Lane	**Full-time suitability** is Medium or High
ENFORCEMENT		
E1	Police enforcement	**Full time suitability** is Low
E2	Bus mounted Camera	**Full time suitability** is Medium or High
E3	Stationary Camera	**Full time suitability** is High
TRANSIT SIGNAL PRIORITY		
T1	Center to Center systems	**TSP suitability** is Medium or High
T2	GPS based System	

Table 9 Cost Considerations for RED Lanes

Code	Cost Element	Capital Cost		Maintenance cost	
LANE TYPE					
L1	Standard Bus Lane – White Pavement Striping	$200,000	per mile	$10,000	per mile per year
L2	Red Paint Bus Lane	$580,000	per mile	$10,000	per mile per year (to be repainted every 5 years)
ENFORCEMENT					
E1	Police enforcement			$75,000	1500 hours of enforcement per year per mile
E2	Bus mounted Camera	$95,000	for 10 buses running on a route at 15-minute headway	$7,500	for 10 buses per year
E3	Stationary Camera	$130,000	4 cameras per mile	$40,000	per mile per year
TRANSIT SIGNAL PRIORITY					
T1	Center to Center systems	$200,000 to $600,000	Depending on the total number of TSP intersections		
T2	GPS based System	$ 5,000	per bus		
		$ 10,000	per intersection		

What's Next for RED Lanes in the CAMPO Region?

Local Application

Local agencies responsible for transportation planning are encouraged to avail themselves of all materials developed as part of the RED Lanes study, including the RED Lanes Toolkit, to identify RED Lanes candidates, initialize appropriately scoped planning studies, and understand the general expected magnitude of investment required. These local agencies will champion the development of specific RED Lanes projects.

The RED Lanes Toolkit makes the analytic databases and computational processes used to generate suitability scores available to CAMPO staff, its member jurisdictions, and partner agencies. The toolkit facilitates testing of alternative values for weighting the importance of different input metrics, conducting scenario planning for transportation or land use planning purposes, and replicating the prioritization process on a regular basis as regional conditions evolve over time. It lays the groundwork for incorporating RED Lanes analysis into ongoing and future studies and is supported by the *RED Lanes Toolkit User Guide*.

The Scoping Sheet Menu, provided as Appendix B, aids in generating Candidate Corridor Scoping Sheets based on RED Lanes Toolkit outputs. The scoping sheets frame appropriate planning emphases and provide rough cost estimates for RED Lanes implementation through brief interpretation of toolkit outputs.

These materials and tools are provided to enable partner agencies and jurisdictions to incorporate RED Lanes into ongoing and future planning efforts.

Updating the RED Lanes Toolkit

CAMPO will maintain the RED Lanes Evaluation Methodology and RED Lanes Toolkit used to generate suitability, Detailed Differentiator, and Implementation Guidance scores. CAMPO will collaborate with member jurisdictions on application of the approaches described in this report to provide assistance in identifying and advancing candidate transit priority projects, with local jurisdictions and partner agencies championing potential projects as noted above.

Formal maintenance of the evaluation process and/or toolkit will occur at CAMPO's discretion. Expected maintenance includes routine updates of supporting data, such as current or planned transit service frequencies, on-time performance information, and fresh ridership, volume, and vehicle operations forecasts from the Triangle Regional Model. Additional, periodic updates to the RED Lanes Evaluation Methodology may be considered, tested, and adopted for use throughout the region. These methodological updates may emerge from the experiences of CAMPO staff and/or agency partners' use of the RED Lanes Toolkit, as a result of the availability of new data that support new or improved metrics, or through changes in best practices highlighted in the transit planning industry or shifting planning emphases in the CAMPO region.

The CTT identified several opportunities for enhancements to the RED Lanes Evaluation Methodology during its development. Data availability, forecasting precision, and/or concerns related to computational complexity or regional consistency in methodology precluded these concepts being incorporated into the first round of RED Lanes suitability scores. Key ideas for potential enhancement are recorded here for future reference. The CTT offered specific feedback regarding the transit OTP metric, aiming to generate more meaningful measures of transit reliability to supplement, refine, or replace OTP. Suggested improvements include tracking headway adherence and/or travel time degradation over time. These measures respond to the possibility that OTP can be maintained through schedule revisions, even as transit travel times may be degrading. Tracking transit route or segment travel times over an extended period is likely to provide more meaningful insight into where RED Lanes can alleviate delays that impact transit vehicles. Additionally, for high-frequency routes, headway adherence is preferred to OTP as a reliability measure. Finally, for all transit reliability measures, focusing on peak-period travel (during the AM and/or PM commuting periods) may provide better insight than daily metrics, which can understate the severity of reliability issues experienced when travel demand is highest. As data supporting these measures become more readily available, they may be incorporated into the RED Lanes Evaluation Methodology.

Additional CTT discussion centered on dimensional scores and weights. The values established in the RED Lanes Evaluation Methodology represent appropriate values for regional application based on observed data ranges, applicable literature, and input from CAMPO staff, the CTT, and the CAMPO Technical Coordinating Committee (TCC). Updates to scoring parameters (score thresholds and/or dimensional weights) are supported by the RED Lanes toolkit, allowing CAMPO staff, local jurisdictions, and partner agencies to test revise weightings as part of project development or updates to the regional RED Lanes process.

Finally, Table 10 lists some potential additional data sources identified in the *Existing Conditions Report* to enhance the RED Lanes Evaluation Methodology over time. These provide a starting point for augmenting and refining the toolkit. Additional datasets may be identified by local partners as the RED Lanes Toolkit is deployed for planning applications.

Table 10 Potential Datasets for Consideration in Future Updates to the RED Lanes Evaluation Methodology

Dataset	Metrics Supported
HERE Traffic Analytics or similar **Source:** https://www.here.com/products/traffic-solutions/road-traffic-analytics **Notes:** Vendor data	• Average historical speed by segment
LODES OD data **Source:** https://lehd.ces.census.gov/data/ **Notes:** 2017 is most current year available at time of writing	• Commute origin-destination patterns by block or higher level of aggregation
Transit Agency APC data or other usage/reliability information **Source:** Direct share from agencies **Notes:** Stop-level boarding and alighting activity could support more robust segment level transit ridership analysis.	• Stop boarding/alighting activity • Headway adherence • Travel time degradation
NC OneMap Parcel Data **Source:** http://data.nconemap.gov/downloads/vector/parcels/ **Notes:** Fine-grained parcel data could allow more robust exploration of adjacent land uses and/or support a context classification analysis that could inform RED Lane design choices.	• Parcel boundaries • Building square footage • Land use category supporting LU diversity analysis

Appendix A - Table of RED Lanes Evaluation Results

Segment Info			RED Lanes	Suitability	Detailed Differentiators		Implementation Guidance		
Route	From	To	Suitability	Category	Comm. Of Concern	Feasibility	Full Time Suit.	TSP Suit.	Nonmotor. Propensity
Glenwood Ave	Creedmoor Rd	Blue Ridge Rd	9	High	2	2	3	2	2
Capital Blvd	Sumner Blvd	Spring Forest Rd	8	High	3	3	2	2	2
Capital Blvd	Spring Forest Rd	Sumner Blvd	8	High	3	3	2	2	2
S Blount St	E Morgan St	E Davie St	8	High	1	3	3	2	3
Western Blvd	Clanton St / Whitmore Dr	Varsity Dr	8	High	3	2	3	2	2
Glenwood Ave	Blue Ridge Rd / Lead Mine Rd	Creedmoor Rd	8	High	2	2	3	2	2
E Edenton St / W Edenton St	N Person St	N Mcdowell St	8	High	1	2	3	2	3
N Salisbury St / S Salisbury St	W Lane St / E Lane St	W Davie St	8	High	1	2	3	2	3
W Martin St	Fayetteville St	S West St	8	High	1	2	2	2	3
Founders Dr	Current Dr	Dan Allen Dr	8	High	1	2	2	3	3
N Dawson St / S Dawson St	W Lane St	W Davie St	8	High	1	2	3	2	3
S Mcdowell St / N Mcdowell St	W Cabarrus St	W Johnson St	8	High	1	2	3	2	3
Hillsborough St	Henderson St	Gardner St	8	High	2	1	3	3	3
E Morgan St	Glenwood Ave	S Blount St	8	High	1	1	3	2	3
Hillsborough St	Pullen Rd	Gardner St	8	High	1	1	3	3	3
Louisburg Rd	Capital Blvd	Batts Rd	7	Medium High	3	3	2	2	2
Capital Blvd	Spring Forest Rd	E Millbrook Rd	7	Medium High	3	3	3	2	2
Capital Blvd	N New Hope Rd	Spring Forest Rd	7	Medium High	3	3	3	2	2
S Blount St	E Davie St	Martin Luther King Jr Blvd	7	Medium High	1	3	2	3	3
Capital Blvd		Wade Ave	7	Medium High	1	3	1	2	2
Capital Blvd	Old Buffaloe Rd	Louisburg Rd	7	Medium High	1	3	2	2	2
Capital Blvd	Capital Blvd	Old Buffaloe Rd	7	Medium High	1	3	2	2	2
Western Blvd	Crossover	Martin Luther King Jr Blvd	7	Medium High	3	2	2	2	3
S Wilmington St	S Wilmington St	I 40 WB	7	Medium High	3	2	2	3	3
Blue Ridge Rd	Lake Boone Trl	Macon Pond Rd	7	Medium High	3	2	3	2	3
S Person St / N Person St	Hoke St	E Edenton St	7	Medium High	3	2	3	2	3
E Millbrook Rd	E Millbrook Rd	Capital Blvd	7	Medium High	3	2	3	2	2
E Edenton St	New Bern Ave	N Person St	7	Medium High	3	2	2	1	3
New Bern Ave	Seawell Ave	Heath St	7	Medium High	3	2	2	2	3
Martin Luther King Jr Blvd	S Wilmington St	Ellington St	7	Medium High	3	2	3	2	3
Martin Luther King Jr Blvd	Holmes St / Chavis Way	Rock Quarry Rd	7	Medium High	3	2	3	2	1
Shanta Dr / Sunnybrook Rd	Shanta Dr	Holston Ln	7	Medium High	3	2	2	2	3
S Wilmington St	Keeter Center Dr / City Farm Rd	S Wilmington St	7	Medium High	3	2	2	3	3
Glenwood Ave	Hillsborough St	W Peace St	7	Medium High	3	2	3	3	3
Western Blvd	Martin Luther King Jr Blvd / S Mcdowell St	Hunt Dr	7	Medium High	3	2	2	2	3
Western Blvd	Nazareth St	I 440 Exit 2 Ramp EB	7	Medium High	3	2	3	2	2
S Saunders St	Lake Wheeler Rd	W Lenoir St	7	Medium High	3	2	2	2	3
S Salisbury St	W Davie St	S Wilmington St	7	Medium High	3	2	2	1	3
Keeter Center Dr	City Farm Rd / S Wilmington St	MCLENDON ST	7	Medium High	3	2	2	3	3
N New Hope Rd	Capital Blvd	E Millbrook Rd	7	Medium High	3	2	3	2	2
S Wilmington St	S Wilmington St	Fayetteville Rd	7	Medium High	3	2	2	3	2
New Bern Ave	Trawick Rd	Beacon Lake Dr	7	Medium High	3	2	2	2	1
Fayetteville Rd	Kitchen Dr	Annaron Ct	7	Medium High	3	2	2	2	1
S Wilmington St	Fayetteville Rd	S Wilmington St	7	Medium High	3	2	3	2	2
S Mcdowell St	S Mcdowell St To Martin L Ramp	W Cabarrus St	7	Medium High	3	2	2	2	3
Kildaire Farm Rd	Laver Dr / Glasgow Rd	SE Maynard Rd / SW Maynard Rd	7	Medium High	3	2	3	2	2
E Six Forks Rd	Anderson Dr	Wake Forest Rd	7	Medium High	3	2	3	2	2
Fayetteville Rd	Manor Ridge Dr	Caddy Rd	7	Medium High	3	2	3	2	1
New Bern Ave	Corporation Pkwy	Trawick Rd	7	Medium High	3	2	2	2	1
Blue Ridge Rd	Beryl Rd	District Dr	7	Medium High	2	2	3	3	3
Lead Mine Rd	Glenwood Ave	Philcrest Rd	7	Medium High	2	2	3	2	2
Atlantic Ave	Merrill Ct	New Hope Church Rd	7	Medium High	2	2	3	2	3
Blue Ridge Rd	Duraleigh Rd	Forestview Rd	7	Medium High	2	2	3	2	3
Wake Forest Rd	St Albans Dr	Colby Dr	7	Medium High	2	2	3	2	3
Spring Forest Rd	Falls Of Neuse Rd	Andsley Dr	7	Medium High	2	2	3	2	2
Fayetteville Rd	SHADY SUMMIT WAY	Brookwood Dr / Manor Ridge Dr	7	Medium High	2	2	3	2	1
Creedmoor Rd	Glenwood Ave	Sugar Bush Rd	7	Medium High	2	2	3	2	2
Creedmoor Rd	Sherborne Pl	W Millbrook Rd	7	Medium High	2	2	3	2	2
S Main St	Capcom Ave	Selsey Dr	7	Medium High	1	2	3	2	1
Hillsborough St	Linda Murphy Dr	I 440 EB	7	Medium High	1	2	3	3	3

Segment Info			RED Lanes	Suitability	Detailed Differentiators		Implementation Guidance		
Route	From	To	Suitability	Category	Comm. Of Concern	Feasibility	Full Time Suit.	TSP Suit.	Nonmotor. Propensity
Hillsborough St	I 440 EB	Blue Ridge Rd / Hillsborough St	7	Medium High	1	2	3	3	3
Creedmoor Rd	Glenwood Ave	Manor Park Dr	7	Medium High	1	2	3	2	2
Hillsborough St	I 440 EB	Henderson St	7	Medium High	1	2	2	3	2
W Peace St / E Peace St	W Peace St To Capital Blv Ramp NB	N Blount St	7	Medium High	1	2	2	2	3
N Wilmington St	S Wilmington St	E Edenton St	7	Medium High	1	2	3	2	3
N Harrison Ave	Chapel Hill Rd	W Chatham St	7	Medium High	1	2	3	2	2
W Cabarrus St	S Salisbury St	S West St	7	Medium High	1	2	2	2	3
W Davie St	Fayetteville St	Commerce Pl	7	Medium High	1	2	2	2	3
E Davie St	Fayetteville St	S Bloodworth St	7	Medium High	1	2	3	2	3
E Hargett St	Fayetteville St	S Bloodworth St	7	Medium High	1	2	3	2	3
Dorothea Dr	S Boylan Ave	W Cabarrus St	7	Medium High	1	2	3	2	3
Gorman St	Thistledown Dr	Avent Ferry Rd	7	Medium High	1	2	2	2	1
Glenwood Ave / Wade Ave	Williamson Dr	Capital Blvd	7	Medium High	1	2	2	1	3
S Wilmington St / US 70 Hwy W	Fayetteville Rd	Mechanical Blvd	7	Medium High	1	2	3	3	2
Louisburg Rd	Fox Rd	Harnett Dr	7	Medium High	1	2	3	2	1
Six Forks Rd	Dublin Rd	W Millbrook Rd / E Millbrook Rd	7	Medium High	1	2	2	2	2
Six Forks Rd	North Glen Dr	Ramblewood Dr	7	Medium High	1	2	2	2	2
Hillsborough St	Park Ave	Hillsborough St / Glenwood Ave	7	Medium High	2	1	3	3	3
Hillsborough St	Gardner St	Oberlin Rd	7	Medium High	1	1	3	3	3
E Martin St	Fayetteville St	S Bloodworth St	7	Medium High	1	1	3	2	3
Capital Blvd	Capital Blvd To I 540 Ramp WB	Sumner Blvd	6	Medium High	3	3	2	2	2
Capital Blvd	Calvary Dr	Capital Blvd	6	Medium High	3	3	2	2	2
Louisburg Rd	Capital Blvd	Capital Blvd	6	Medium High	3	3	2	2	2
Fayetteville Rd	S Wilmington St	Fayetteville Rd	6	Medium High	3	3	2	3	2
Capital Blvd	Louisburg Rd	N New Hope Rd	6	Medium High	3	3	2	2	2
Wake Forest Rd	Wake Forest Rd	Wake Forest Rd	6	Medium High	3	3	2	2	2
Capital Blvd	I 440 Exit 11 Ramp EB	I 440 EB	6	Medium High	2	3	1	2	2
I 440 WB	Capital Blvd	I 440 Exit 11 Ramp WB	6	Medium High	2	3	2	2	2
I 440 EB	Capital Blvd To I 440 Ramp EB	Capital Blvd	6	Medium High	2	3	2	2	2
Capital Blvd	Sumner Blvd	I 540 Ramp EB	6	Medium High	2	3	2	2	2
Arco Corporate Dr	Brier Creek Pkwy	Arco Corporate Dr	6	Medium High	1	3	2	2	2
Timber Dr E / Timber Dr	White Oak Rd	Timber Dr	6	Medium High	1	3	2	2	1
Glenwood Ave	Brier Creek Pkwy	Glenwood Ave To I 540 Ramp	6	Medium High	1	3	2	2	2
Capital Blvd	Highwoods Blvd	Mayflower Dr	6	Medium High	1	3	2	2	2
Capital Blvd	Mayflower Dr	Highwoods Blvd	6	Medium High	1	3	2	2	2
Glenwood Ave	Womans Club Dr	I 440 Exit 7 Ramp EB	6	Medium High	1	3	3	2	2
Glenwood Ave	I 540 Exit 4 Ramp WB	Brier Creek Pkwy	6	Medium High	1	3	2	2	1
Poole Rd	Bus Way	Carya Dr	6	Medium High	3	2	2	2	1
Poole Rd	Cardamon Ct	Poole Rd	6	Medium High	3	2	1	2	3
Western Blvd	Pineland Cir	Clanton St / Whitmore Dr	6	Medium High	3	2	3	1	1
Western Blvd	Varsity Dr	Crossover	6	Medium High	3	2	2	3	2
Morrill Dr / Avent Ferry Rd	Western Blvd	Athens Dr	6	Medium High	3	2	3	3	2
SE Maynard Rd / SW Maynard Rd	Wilshire Dr	Kilmayne Dr	6	Medium High	3	2	2	2	2
S Wilmington St	I 40 WB	S Saunders St	6	Medium High	3	2	2	1	2
Hammond Rd	US 70 Hwy W	Hammond Center Dr	6	Medium High	3	2	2	1	2
E Millbrook Rd	Old Wake Forest Rd	Flint Ridge Pl	6	Medium High	3	2	3	2	2
Spring Forest Rd	Dixie Forest Rd	Hollenden Dr	6	Medium High	3	2	3	1	2
N New Hope Rd	N New Hope Rd	Kincaid Dr	6	Medium High	3	2	2	2	1
E Millbrook Rd	Old Wake Forest Rd	E Millbrook Rd	6	Medium High	3	2	3	2	3
E Millbrook Rd / N New Hope Rd	Capital Blvd	Louisburg Rd	6	Medium High	3	2	3	2	2
S Raleigh Blvd	Rock Quarry Rd	Poole Rd	6	Medium High	3	2	2	2	1
New Bern Ave	Farris Ct / Clarendon Cres	I 440 WB	6	Medium High	3	2	2	2	3
Old Wake Forest Rd	Capital Blvd	Barrow Dr / Sumner Blvd	6	Medium High	3	2	3	2	2
Martin Luther King Jr Blvd	Ellington St	Holmes St / Chavis Way	6	Medium High	3	2	2	2	3
E Chatham St	NE Maynard Rd / SE Maynard Rd	E Circle Dr	6	Medium High	3	2	2	1	2
New Bern Ave / E Edenton St	N Raleigh Blvd	Poole Rd / E Edenton St	6	Medium High	3	2	3	2	2
S Wilmington St	S Saunders St	I 40 EB	6	Medium High	3	2	2	1	2
Western Blvd	Hunt Dr	Nazareth St	6	Medium High	3	2	2	1	3
Western Blvd	I 440 Exit 2 Ramp EB	Pineland Cir	6	Medium High	3	2	3	1	1
Rock Quarry Rd / Blazing Star Ln	Merrywood Dr	S Raleigh Blvd	6	Medium High	3	2	2	2	1

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Route	From	To	Suitability	Category	Comm. Of Concern	Feasibility	Full Time Suit.	TSP Suit.	Nonmotor. Propensity
Atlantic Ave	Forest Oaks Dr	Litchford Rd	6	Medium High	3	2	2	2	3
NW Maynard Rd	Chapel Hill Rd	NW Maynard Rd	6	Medium High	3	2	3	3	2
Poole Rd	New Bern Ave	Russ St	6	Medium High	3	2	1	2	3
Waldrop St	Boyer St	Oakwood Ave	6	Medium High	3	2	2	2	1
Western Blvd To S Dawson Ramp SB	Western Blvd	S Dawson St	6	Medium High	3	2	2	2	3
Martin Luther King Jr Blvd	S Blount St	Western Blvd / S Mcdowell St	6	Medium High	3	2	2	2	3
Spring Forest Rd	SPRING FALLS DR / Ridgefield Dr	Falls Of Neuse Rd	6	Medium High	3	2	3	2	2
Lake Wheeler Rd	Village Bluff Pl	Lineberry Dr	6	Medium High	3	2	3	1	1
S Raleigh Blvd	N Raleigh Blvd	Martin Luther King Jr Blvd	6	Medium High	3	2	2	3	1
S Dawson St / S Saunders St	W Davie St	S Wilmington St	6	Medium High	3	2	2	2	3
Spring Forest Rd	Greens Dairy Rd	Spring Ct	6	Medium High	3	2	3	1	2
S Saunders St	S Wilmington St	Summit Ave	6	Medium High	3	2	1	2	2
Rock Quarry Rd	Pearl Rd	Interlock Dr	6	Medium High	3	2	2	2	1
Rock Quarry Rd	Fox Ridge Manor Rd	Rock Quarry Rd	6	Medium High	3	2	2	2	1
Hammond Rd / Timber Dr	Hammond Center Dr	US 70 Hwy W	6	Medium High	3	2	3	1	2
Fayetteville Rd	Fayetteville Rd	Manor Ridge Dr	6	Medium High	3	2	3	2	1
Fayetteville Rd		Scott Rd	6	Medium High	3	2	3	2	1
New Bern Ave	Trawick Rd	I 440 EB	6	Medium High	3	2	2	2	1
I 440 EB	New Bern Ave	I 440 Exit 13 Ramp EB	6	Medium High	3	2	2	2	1
Blue Ridge Rd	District Dr	Lake Boone Trl	6	Medium High	2	2	2	3	3
Blue Ridge Rd / Duraleigh Rd	Macon Pond Rd	Edwards Mill Rd	6	Medium High	2	2	3	1	3
N Raleigh Blvd	Oakwood Ave	Park Glen Dr	6	Medium High	2	2	2	3	1
NW Maynard Rd	NW Maynard Rd	Chapel Hill Rd	6	Medium High	2	2	3	3	2
W Chatham St	N Academy St	Old Apex Rd	6	Medium High	2	2	3	2	2
New Hope Church Rd	Arrowwood Dr	Craftsman Dr	6	Medium High	2	2	2	2	3
Wake Forest Rd / Atlantic Ave	Capital Blvd	Merrill Ct	6	Medium High	2	2	3	2	2
Kildaire Farm Rd	SE Maynard Rd / SW Maynard Rd	W Cornwall Rd / E Cornwall Rd	6	Medium High	2	2	3	2	2
Hillsborough St	Hillsborough St	Park Ave	6	Medium High	2	2	2	3	3
Sumner Blvd	Capital Blvd	Melville Dr	6	Medium High	2	2	2	1	2
Highwoods Blvd	Poplarwood Ct	Wolfpack Ln / Atlantic Ave	6	Medium High	2	2	2	2	3
Blue Ridge Rd	Forestview Rd	District Dr	6	Medium High	2	2	2	3	3
Wake Forest Rd	Colby Dr	Ronald Dr / Ollie St	6	Medium High	2	2	3	2	3
Spring Forest Rd	Andsley Dr	Quail Ridge Rd	6	Medium High	2	2	3	2	2
Ederlee Dr / Regency Pkwy	Peregrine Pl	Tryon Rd	6	Medium High	2	2	2	2	2
Creedmoor Rd	Sugar Bush Rd	Sherborne Pl	6	Medium High	2	2	3	2	1
Buffaloe Rd	Bison Hill Ln	Capital Blvd	6	Medium High	2	2	2	1	2
Creedmoor Rd	Glenwood Ave	Plaza Pl	6	Medium High	2	2	3	2	1
S Main St	Carter St	Capcom Ave	6	Medium High	1	2	3	2	1
NC 55 Hwy	Morrisville Pkwy	Indian Wells Rd / Morrisville Carpenter Rd	6	Medium High	1	2	2	2	1
Chapel Hill Rd	Summit Ridge Loop	Linda Dr	6	Medium High	1	2	2	1	2
Chapel Hill Rd	NE Maynard Rd	Trinity Rd	6	Medium High	1	2	2	3	2
Chapel Hill Rd	Chapel Hill Rd	Chapel Hill Rd	6	Medium High	1	2	2	3	2
NC 55 Hwy	Carpenter Fire Station Rd	Morrisville Pkwy	6	Medium High	1	2	2	2	1
Aviation Pkwy	National Guard Dr	I 40 Ramp EB	6	Medium High	1	2	3	3	1
Walnut St	SE Maynard Rd	Kingston Ridge Rd	6	Medium High	1	2	2	3	2
NE Maynard Rd / SE Maynard Rd	Chapel Hill Rd	Ashe Ave	6	Medium High	1	2	3	3	2
NW Maynard Rd	Old Apex Rd	High House Rd	6	Medium High	1	2	3	3	1
Cary Towne Blvd	SE Maynard Rd	Convention Dr / Principal Ln	6	Medium High	1	2	3	1	2
Wade Ave	Dixie Trl	I 440 Exit 4 Ramp EB	6	Medium High	1	2	2	1	2
Lead Mine Rd	Philcrest Rd	Yorkgate Dr	6	Medium High	1	2	3	2	2
N Person St	Pace St	Capital Blvd	6	Medium High	1	2	1	2	2
Ponderosa Service Rd	Ponderosa Park Dr	Falls Of Neuse Rd / Capital Blvd	6	Medium High	1	2	2	2	1
Star Rd	S Main St	Star Rd	6	Medium High	1	2	2	2	1
New Bern Ave	S Blount St	Seawell Ave	6	Medium High	1	2	2	2	3
Airport Blvd	Slater Rd	I 40 Ramp WB	6	Medium High	1	2	3	2	2
Brier Creek Pkwy	Glenwood Ave	Brier Creek Pkwy	6	Medium High	1	2	3	2	1
S Blount St	N Blount St	E Morgan St	6	Medium High	1	2	2	2	3
W Peace St	Clark Ave	Capital Blvd To W Peace S Ramp EB	6	Medium High	1	2	2	2	3
New Bern Ave	I 440 EB / New Bern Ave	Clarendon Cres	6	Medium High	1	2	2	2	3
N Wilmington St	E Edenton St	N Salisbury St / Halifax St	6	Medium High	1	2	3	2	3

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Route	From	To	Suitability	Category	Comm. Of Concern	Feasibility	Full Time Suit.	TSP Suit.	Nonmotor. Propensity
Glenwood Ave	W Peace St	Wade Ave	6	Medium High	1	2	2	2	3
Regency Pkwy	Tryon Rd	Regency Forest Dr	6	Medium High	1	2	2	2	2
Cary Pkwy	Olde Weatherstone Way	Village Market Pl	6	Medium High	1	2	2	2	2
Wade Ave	I 440 Exit 4 Ramp EB	Wade Ave	6	Medium High	1	2	2	1	2
Faucette Dr	Morrill Dr	Gorman St	6	Medium High	1	2	3	3	2
Falls Of Neuse Rd	Grove Ridge Rd	Forest Pines Dr	6	Medium High	1	2	3	2	1
E Lenoir St	Fayetteville St	S Bloodworth St	6	Medium High	1	2	2	2	3
E Lane St	N Salisbury St	N Person St	6	Medium High	1	2	2	2	3
Glenwood Ave	Wade Ave	W Peace St	6	Medium High	1	2	2	2	3
Wake Forest Rd	E Whitaker Mill Rd	St Albans Dr	6	Medium High	1	2	2	2	2
Falls Of Neuse Rd	Sandy Forks Rd	Durant Rd	6	Medium High	1	2	2	2	1
Lynn Rd / Spring Forest Rd	Six Forks Rd	Shanda Dr / North Bend Dr	6	Medium High	1	2	3	2	2
Tryon Rd	Lake Wheeler Rd	Trailwood Dr	6	Medium High	1	2	2	1	1
Cary Towne Blvd	Principal Ln	SE Maynard Rd	6	Medium High	1	2	3	1	2
Glenwood Ave	I 540 Exit 4 Ramp EB	Fleetwood Dr	6	Medium High	1	2	3	2	1
Glenwood Ave	Morehead Dr	Creedmoor Rd	6	Medium High	1	2	2	2	2
Glenwood Ave	Blue Ridge Rd	Pasquotank Dr	6	Medium High	1	2	3	2	2
Glenwood Ave	Oberlin Rd	The Circle	6	Medium High	1	2	3	3	2
Glenwood Ave	Glenwood Ave	White Oak Rd	6	Medium High	1	2	3	2	2
Glenwood Ave	White Oak Rd	Glenwood Ave	6	Medium High	1	2	2	2	2
Glenwood Ave	Glenwood Ave	Williamson Dr	6	Medium High	1	2	2	2	2
Walnut St	Buck Jones Rd	Walnut St	6	Medium High	1	2	3	3	2
Fayetteville Rd	Crossover	Gelder Dr	6	Medium High	1	2	2	3	1
Fayetteville Rd	Brookwood Dr / Manor Ridge Dr	Kitchen Dr	6	Medium High	1	2	3	2	1
Fayetteville Rd	Annaron Ct	S Wilmington St	6	Medium High	1	2	2	3	2
Capital Blvd	Wake Forest Rd	Capital Blvd To I 440 Ramp EB	6	Medium High	1	2	1	2	2
Louisburg Rd	Harnett Dr	Perry Creek Rd	6	Medium High	1	2	3	2	1
Capital Blvd	Falls Of Neuse Rd	Star Rd / Ponderosa Service Rd	6	Medium High	1	2	2	2	1
High House Rd	Davis Dr	Cavendish Dr	6	Medium High	1	2	3	3	1
Wade Ave	Capital Blvd	Glenwood Ave	6	Medium High	1	2	2	2	3
Glenwood Ave	White Oak Rd	Glenwood Ave	6	Medium High	1	2	3	2	2
Glenwood Ave	Westborough Dr / Pinecrest Rd	Glenwood Ave Ramp	6	Medium High	1	2	3	2	1
Kildaire Farm Rd	Crescentcommons Dr / Bald Eagle Ln	Laver Dr / Glasgow Rd	6	Medium High	1	2	3	2	2
Six Forks Rd	Mine Lake Ct	Dublin Rd	6	Medium High	1	2	3	2	2
Six Forks Rd	W Millbrook Rd / E Millbrook Rd	North Glen Dr	6	Medium High	1	2	2	2	2
Six Forks Rd	Ramblewood Dr	Anderson Dr	6	Medium High	1	2	2	2	2
Louisburg Rd	Perry Creek Rd	Harnett Dr	6	Medium High	1	2	3	2	1
Capital Blvd	I 440 Exit 11 Ramp WB	Crossover	6	Medium High	1	2	1	2	2
Capital Blvd	Wake Forest Rd	Wake Forest Rd To Capital Ramp SB	6	Medium High	1	2	1	2	2
Capital Blvd	Star Rd	Falls Of Neuse Rd / S Main St	6	Medium High	1	2	2	2	1
Cross Link Rd	Seabrook Rd	Dandridge Dr	6	Medium High	3	1	3	3	1
Athens Dr	Jones Franklin Rd	Kaplan Dr	6	Medium High	3	1	3	2	2
Pullen Rd	Hillsborough St	Western Blvd	6	Medium High	3	1	2	3	3
Chavis Way	E Lenoir St	Holmes St / Martin Luther King Jr Blvd	6	Medium High	3	1	2	1	3
Calvary Dr		Louisburg Rd	6	Medium High	3	1	3	1	2
Edwards Mill Rd	Reedy Creek Rd		6	Medium High	2	1	2	3	3
Oberlin Rd	Smallwood Dr	Hillsborough St	6	Medium High	2	1	3	3	3
Edwards Mill Rd	Wade Ave Ramp WB	Reedy Creek Rd	6	Medium High	2	1	2	3	3
S Main St	Spring Park Rd	Dr Calvin Jones Hwy	6	Medium High	1	1	3	2	1
Glascock St	Watauga St	Bennett St	6	Medium High	1	1	2	2	2
St Marys St	W Morgan St	W Peace St	6	Medium High	1	1	3	1	3
St Marys St	Anderson Dr	Wedgedale Dr	6	Medium High	1	1	2	3	2
Lassiter Mill Rd	May Ct	Lassiter At North Hills Ave	6	Medium High	1	1	2	3	2
W Whitaker Mill Rd	Fairview Rd	Mccarthy St	6	Medium High	1	1	2	1	2
Oberlin Rd	Glenwood Ave	Dodd Ln	6	Medium High	1	1	2	3	2
W Jones St	N Salisbury St	N Dawson St	6	Medium High	1	1	3	2	3
Morrill Dr	Cates Ave	Western Blvd	6	Medium High	1	1	3	3	2
Capital Blvd	E Millbrook Rd	Calvary Dr	5	Medium Low	3	3	2	2	2
Capital Blvd	I 540 Ramp EB	Perry Creek Rd / Durant Rd	5	Medium Low	2	3	2	2	1
N Person St	E Edenton St	Pace St	5	Medium Low	1	3	2	2	3

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Route	From	To	Suitability	Category	Comm. Of Concern	Feasibility	Full Time Suit.	TSP Suit.	Nonmotor. Propensity
Cheviot Hills Dr	Gresham Lake Rd	Jacqueline Ln / Capital Blvd	5	Medium Low	1	3	2	2	1
Falls Of Neuse Rd	Old Falls Of Neuse Rd	Waterwood Ct	5	Medium Low	1	3	2	2	1
Automotive Way	Wake Forest Rd	Capital Blvd	5	Medium Low	1	3	2	2	2
N Harrison Ave	Star Ln	NW Cary Pkwy	5	Medium Low	1	3	2	2	2
Capital Blvd	Mayflower Dr	Old Buffaloe Rd	5	Medium Low	1	3	2	2	2
Capital Blvd	Durant Rd	Capital Blvd To I 540 Ramp WB	5	Medium Low	1	3	2	2	1
Capital Blvd	Old Buffaloe Rd	Mayflower Dr	5	Medium Low	1	3	2	2	2
Poole Rd	Barwell Rd	Hickory Hollow Ln / Maybrook Dr	5	Medium Low	3	2	2	2	1
Poole Rd	S New Hope Rd	Bus Way	5	Medium Low	3	2	1	2	1
Poole Rd	Carya Dr	Cardamon Ct	5	Medium Low	3	2	1	2	3
Western Blvd	Carolina Ave	Pineland Cir	5	Medium Low	3	2	2	1	1
SW Maynard Rd	Kilmayne Dr	Old Apex Rd	5	Medium Low	3	2	2	3	2
Blue Ridge Rd	Western Blvd	Faber Dr	5	Medium Low	3	2	2	3	1
Hammond Rd	Hammond Center Dr	I 40 Exit 299 Ramp WB	5	Medium Low	3	2	3	1	1
Perry Creek Rd	Louisburg Rd	Liston Dr / Filbin Creek Dr	5	Medium Low	3	2	3	2	1
N New Hope Rd	Kincaid Dr	Louisburg Rd	5	Medium Low	3	2	2	2	1
Skycrest Dr	Trawick Rd	N New Hope Rd	5	Medium Low	3	2	2	1	1
Sunnybrook Rd	Middle Branch Rd	Poole Rd	5	Medium Low	3	2	2	2	3
S Raleigh Blvd / N Raleigh Blvd	Poole Rd	Oakwood Ave	5	Medium Low	3	2	2	2	1
New Bern Ave	Heath St	Farris Ct / Clarendon Cres	5	Medium Low	3	2	3	2	1
Chapel Hill Rd	NW Maynard Rd	Chesterfield Dr	5	Medium Low	3	2	2	1	2
Old Wake Forest Rd	Barrow Dr / Sumner Blvd	Old Wake Forest Rd	5	Medium Low	3	2	2	2	2
S Blount St	Martin Luther King Jr Blvd	Hoke St	5	Medium Low	3	2	2	2	3
Martin Luther King Jr Blvd	S Mcdowell St	S Wilmington St	5	Medium Low	3	2	2	2	3
Hillsborough St / E Chatham St	Bashford Rd	Soccer Park Dr	5	Medium Low	3	2	2	1	2
N New Hope Rd	Louisburg Rd	N New Hope Rd	5	Medium Low	3	2	1	2	2
N New Hope Rd	Woodlawn Dr	Sue Ellen Dr	5	Medium Low	3	2	1	2	2
Lake Boone Trl	Wycliff Rd	Thomas Rd	5	Medium Low	3	2	2	2	3
Sunnybrook Rd	Holston Ln	Carl Sandburg Ct	5	Medium Low	3	2	1	2	3
S Wilmington St	I 40 EB	Keeter Center Dr / City Farm Rd	5	Medium Low	3	2	2	1	2
Western Blvd	Pineland Cir	Western Blvd	5	Medium Low	3	2	2	1	3
W Lenoir St	S Saunders St	S Mcdowell St	5	Medium Low	3	2	2	2	3
N Tarboro St / S Tarboro St	E Edenton St	Merrywood Dr	5	Medium Low	3	2	2	3	3
Atlantic Ave	New Hope Church Rd	E Millbrook Rd	5	Medium Low	3	2	2	1	3
Poole Rd	Russ St	Poole Rd	5	Medium Low	3	2	3	1	1
Varsity Dr	Avent Ferry Rd	Main Campus Dr	5	Medium Low	3	2	2	3	2
Green Rd	E Millbrook Rd	Spring Forest Rd	5	Medium Low	3	2	2	2	2
Sunnybrook Rd / Shanta Dr	Carl Sandburg Ct	New Bern Ave	5	Medium Low	3	2	2	2	3
Lake Wheeler Rd	Lake Wheeler Rd	S Saunders St	5	Medium Low	3	2	3	3	3
Spring Forest Rd	Shanda Dr / North Bend Dr	SPRING FALLS DR	5	Medium Low	3	2	2	2	2
Lake Wheeler Rd	Lineberry Dr	Tryon Rd	5	Medium Low	3	2	2	1	1
US 70 Hwy W	Loop Rd	US 70 To Aversboro Rd Ramp SB	5	Medium Low	3	2	3	1	1
New Bern Ave	I 440 WB	Trawick Rd	5	Medium Low	3	2	2	2	1
S Saunders St / S Mcdowell St	Summit Ave	S Mcdowell St To Martin L Ramp	5	Medium Low	3	2	2	2	3
Poole Rd	Poole Rd	S New Hope Rd	5	Medium Low	3	2	2	2	1
Rock Quarry Rd	Battle Bridge Rd	Pearl Rd	5	Medium Low	3	2	2	2	1
Hammond Rd	I 40 WB	Hammond Center Dr	5	Medium Low	3	2	3	1	1
E Six Forks Rd	Wake Forest Rd	Atlantic Ave	5	Medium Low	3	2	2	2	2
Knightdale Blvd	Mcknight Dr	HINTON OAKS BLVD	5	Medium Low	3	2	3	3	1
New Bern Ave	N New Hope Rd	Corporation Pkwy	5	Medium Low	3	2	2	2	2
Davis Dr	Morrisville Carpenter Rd	Mccrimmon Pkwy	5	Medium Low	2	2	2	2	1
W Millbrook Rd / Leesville Rd	Creedmoor Rd	Chatford Dr	5	Medium Low	2	2	3	1	2
Lead Mine Rd	Yorkgate Dr	W Millbrook Rd	5	Medium Low	2	2	3	2	2
Edwards Mill Rd		Trinity Rd	5	Medium Low	2	2	2	3	3
NW Maynard Rd	Weather Ridge Ln	NW Maynard Rd	5	Medium Low	2	2	2	3	2
Davis Dr	Lattner Ct	Morrisville Carpenter Rd	5	Medium Low	2	2	2	2	1
SE Cary Pkwy	Kildaire Farm Rd	Kirkshire Cir	5	Medium Low	2	2	2	2	2
Old Wake Forest Rd	Capital Blvd	Triangle Town Blvd	5	Medium Low	2	2	1	2	2
Old Wake Forest Rd	Triangle Town Blvd	Segal Dr	5	Medium Low	2	2	3	2	2
Highwoods Blvd	Capital Blvd	Poplarwood Ct	5	Medium Low	2	2	1	3	3

Segment Info			RED Lanes	Suitability	Detailed Differentiators		Implementation Guidance		
Route	From	To	Suitability	Category	Comm. Of Concern	Feasibility	Full Time Suit.	TSP Suit.	Nonmotor. Propensity
Duraleigh Rd	W Millbrook Rd / Glenwood Ave	Duraleigh Rd	5	Medium Low	2	2	2	1	2
Wake Forest Rd / Falls Of Neuse Rd	Ronald Dr / Ollie St	Pacific Dr / Bland Rd	5	Medium Low	2	2	2	2	3
Fox Rd	Target Side Dr	FOX FOREST RD	5	Medium Low	2	2	3	2	2
SE Cary Pkwy		High Meadow Dr	5	Medium Low	2	2	2	2	2
Knightdale Blvd	HINTON OAKS BLVD	Crossover	5	Medium Low	2	2	3	3	1
Wendell Blvd	Wendell Blvd	Liles Dean Rd	5	Medium Low	2	2	2	2	1
Rock Quarry Rd	New Birch Dr	Fox Ridge Manor Rd	5	Medium Low	2	2	2	2	1
W Millbrook Rd	Leesville Rd	W Millbrook Rd	5	Medium Low	2	2	3	1	2
S Main St	Capital Blvd	Carter St	5	Medium Low	1	2	3	2	1
N Main St	Lakestone Commons Ave	N Main St	5	Medium Low	1	2	2	3	1
N Broad St / Gb Alford Hwy	James Slaughter Rd	Ralph Stephens Rd	5	Medium Low	1	2	2	3	1
E Williams St		S Tunstall Ave	5	Medium Low	1	2	2	2	1
W Williams St	Apex Pewy	US 64 Ramp EB	5	Medium Low	1	2	2	2	2
NC 55 Hwy	Catlin Rd / Parkscene Ln	Green Level West Rd / High House Rd	5	Medium Low	1	2	2	2	1
NC 55 Hwy	Glendon Way	Morrisville Pkwy	5	Medium Low	1	2	2	2	1
Chapel Hill Rd	Keybridge Dr	Summit Ridge Loop	5	Medium Low	1	2	2	1	2
NC 55 Hwy	MORRISVILLE PKWY / Morrisville Pkwy	NC 55 Hwy	5	Medium Low	1	2	2	2	1
Gb Alford Hwy / N Broad St	Ralph Stephens Rd	James Slaughter Rd	5	Medium Low	1	2	2	3	1
Holly Springs Rd	Grassy Meadow Rd / Flint Point Ln	N Main St	5	Medium Low	1	2	2	3	1
New Hill Rd	Gb Alford Hwy	Old Holly Springs Apex Rd	5	Medium Low	1	2	2	3	1
Walnut St	Kingston Ridge Rd	Meeting St	5	Medium Low	1	2	2	3	2
SE Maynard Rd	Ashe Ave	Ralph Dr	5	Medium Low	1	2	2	3	2
Duraleigh Rd / W Millbrook Rd	Deep Hollow Dr	Glenwood Ave	5	Medium Low	1	2	2	1	2
W Millbrook Rd	Six Forks Rd	Lead Mine Rd	5	Medium Low	1	2	3	2	1
N Raleigh Blvd	Park Glen Dr	I 440 WB	5	Medium Low	1	2	2	3	1
Hillsborough St	Glenwood Ave	W Edenton St / N Mcdowell St	5	Medium Low	1	2	2	3	3
Edwards Mill Rd	Carriage Dr	Reedy Creek Rd	5	Medium Low	1	2	2	3	3
Airport Blvd	Perimeter Park Dr	Slater Rd	5	Medium Low	1	2	1	2	3
Evans Rd	Aviation Pkwy	Weston Pkwy	5	Medium Low	1	2	2	2	2
Hillsborough St	Western Blvd	Burton Ave / Western Blvd	5	Medium Low	1	2	2	1	2
N Salem St	W Chatham St	Salem Church Rd	5	Medium Low	1	2	2	2	1
Buck Jones Rd	Buck Jones Rd	Walnut St	5	Medium Low	1	2	2	3	2
New Bern Ave	Clarendon Cres	N Raleigh Blvd	5	Medium Low	1	2	3	2	1
Cary Pkwy	High House Rd	Olde Weatherstone Way	5	Medium Low	1	2	2	2	2
N Salisbury St	Halifax St / N Wilmington St	W Lane St / E Lane St	5	Medium Low	1	2	2	2	3
Oberlin Rd	Glover Ln	Smallwood Dr	5	Medium Low	1	2	2	3	2
Polk St	N Wilmington St	N East St	5	Medium Low	1	2	1	1	3
Hillsborough St	N Salisbury St / S Salisbury St	Hillsborough St	5	Medium Low	1	2	3	2	3
Falls Of Neuse Rd	Falls Of Neuse Rd	Waterwood Ct	5	Medium Low	1	2	2	2	1
Crabtree Valley Ave	Summit Park Ln / Blue Ridge Rd	Edwards Mill Rd	5	Medium Low	1	2	3	1	3
Brentwood Rd	Brentwood Rd / I 440 Exit 12 Ramp WB	Capital Blvd	5	Medium Low	1	2	2	2	2
Jones Franklin Rd	BATOUL LN	I 40 EB	5	Medium Low	1	2	2	2	2
Jones Franklin Rd	Denise Dr	Barringer Dr	5	Medium Low	1	2	3	2	2
Capital Blvd To Wake Fore Ramp NB	Capital Blvd	E Whitaker Mill Rd	5	Medium Low	1	2	2	2	2
Falls Of Neuse Rd	Durant Rd	Kings Grant Dr / Whittington Dr	5	Medium Low	1	2	2	2	1
Edwards Mill Rd	Arckelton Dr	Crabtree Valley Ave	5	Medium Low	1	2	3	2	3
NW Cary Pkwy	Chapel Hill Rd	High House Rd	5	Medium Low	1	2	2	2	2
Tryon Rd	Piney Plains Rd	Wellingborough Dr	5	Medium Low	1	2	2	2	1
Glenwood Ave	Barrowood Dr	Morehead Dr	5	Medium Low	1	2	2	2	2
Glenwood Ave	Pasquotank Dr	Oberlin Rd	5	Medium Low	1	2	3	2	2
New Bern Ave	Freedom Dr	Old Milburnie Rd	5	Medium Low	1	2	3	3	1
N Main St	S NC 55 Hwy	Ideal Ln / Mill Creek Dr	5	Medium Low	1	2	2	3	1
N Main St	Meadow Dr	Lake Wheeler Rd	5	Medium Low	1	2	2	3	1
Capital Blvd	Wake Forest Rd To Capital Ramp NB	Wake Forest Rd	5	Medium Low	1	2	1	2	2
Louisburg Rd	Midtown Market Ave	Fox Rd	5	Medium Low	1	2	2	2	1
Louisburg Rd	Perry Creek Rd	Mitchell Mill Rd	5	Medium Low	1	2	1	2	1
Capital Blvd	Capital Blvd Ramp	Crossover / Popes Creek Dr	5	Medium Low	1	2	2	2	1
High House Rd	Sir Walker Ln / Cranborne Ln	Davis Dr	5	Medium Low	1	2	2	3	1
W Millbrook Rd	Oldtowne Rd	North Hills Dr	5	Medium Low	1	2	3	2	1
US 64 Hwy W	Gregson Dr	Edinburgh Dr / Edinburgh South Dr	5	Medium Low	1	2	1	2	2

Segment Info			RED Lanes	Suitability	Detailed Differentiators		Implementation Guidance		
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US 70 Hwy W	Vandora Springs Rd	Yeargan Rd	5	Medium Low	1	2	3	1	1
Glenwood Ave	Oberlin Rd	Womans Club Dr	5	Medium Low	1	2	3	2	2
Glenwood Ave	I 440 Exit 7 Ramp EB	Blue Ridge Rd / Lead Mine Rd	5	Medium Low	1	2	2	2	2
Glenwood Ave	Creedmoor Rd	Hilburn Dr	5	Medium Low	1	2	2	2	2
Six Forks Rd	Sawmill Rd / Mourning Dove Rd	Mine Lake Ct	5	Medium Low	1	2	2	2	2
Louisburg Rd	Mitchell Mill Rd / Ligon Mill Rd	Perry Creek Rd	5	Medium Low	1	2	1	2	1
Louisburg Rd	Harnett Dr	Botany Bay Dr	5	Medium Low	1	2	3	2	1
N Main St	Crossover	Meadow Dr	5	Medium Low	1	2	2	3	1
Creedmoor Rd	W Millbrook Rd	Morgans Way	5	Medium Low	1	2	2	2	1
Creedmoor Rd	Bandford Way	Sneedhall Ln	5	Medium Low	1	2	2	2	1
New Bern Ave	Old Milburnie Rd	Raleigh Beach Rd	5	Medium Low	1	2	3	3	1
Capital Blvd	Falls Of Neuse Rd / S Main St	Capital Blvd Ramp	5	Medium Low	1	2	2	2	1
Creedmoor Rd	Plaza Pl	Morgans Way	5	Medium Low	1	2	2	2	1
Creedmoor Rd	Brennan Dr	Sneedhall Ln	5	Medium Low	1	2	2	2	1
Sanderford Rd	Evers Dr	Madelyn Watson Ln	5	Medium Low	3	1	2	3	1
Rush St	Hammond Rd	Disco Ln	5	Medium Low	3	1	3	1	1
Cross Link Rd	Platinum Ave / Hadley Rd	Rock Quarry Rd	5	Medium Low	3	1	3	3	1
Athens Dr	Kaplan Dr	Avent Ferry Rd	5	Medium Low	3	1	3	2	2
Garner Rd	Garner Rd	Peterson St	5	Medium Low	3	1	2	2	1
Gorman St	Avent Ferry Rd	Hillsborough St	5	Medium Low	3	1	2	3	2
Seabrook Rd	Cross Link Rd	Evers Dr	5	Medium Low	3	1	3	3	1
S State St	E Lenoir St	Dandridge Dr / Bunche Dr	5	Medium Low	3	1	2	3	1
Maywood Ave	S Saunders St	Lake Wheeler Rd	5	Medium Low	3	1	3	3	2
Kent Rd	Method Rd / Western Blvd	Kaplan Dr	5	Medium Low	3	1	2	2	2
Kaplan Dr	Gorman St	Kent Rd	5	Medium Low	3	1	2	2	2
Fayetteville St	LEVISTER CT	Maywood Ave	5	Medium Low	3	1	2	3	3
Dandridge Dr	Bunche Dr / S State St	Aaron Dr	5	Medium Low	3	1	3	3	1
Hadley Rd	Dandridge Dr	Platinum Ave / Cross Link Rd	5	Medium Low	3	1	2	3	1
Chapel Hill Rd / Hillsborough St	Mt Vernon Rd	Linda Murphy Dr	5	Medium Low	2	1	2	2	3
Nowell Rd	Sandwell Ln	Chapel Hill Rd	5	Medium Low	2	1	1	1	2
Glascock St	Bennett St	N Raleigh Blvd	5	Medium Low	2	1	2	2	1
Kildaire Farm Rd / S Academy St	W Cornwall Rd / E Cornwall Rd	Waldo St	5	Medium Low	2	1	2	2	2
Edwards Mill Rd	Reedy Creek Rd	Duraleigh Rd	5	Medium Low	2	1	2	3	3
St Albans Dr	Wake Forest Rd	Boddie Dr	5	Medium Low	2	1	2	3	3
E Lane St	Linden Ave	N Tarboro St	5	Medium Low	2	1	2	1	3
Rock Quarry Rd		Old Williams Rd	5	Medium Low	2	1	1	2	1
W Garner Rd	Vandora Springs Rd	Johnson St	5	Medium Low	1	1	2	2	2
Laura Duncan Rd	Oakgate Ct	Laura Village Dr	5	Medium Low	1	1	1	2	1
Trailwood Dr	Main Campus Dr / Thistledown Dr	Tryon Rd	5	Medium Low	1	1	3	1	1
Skycrest Dr / N Raleigh Blvd	Brentwood Rd	I 440 WB	5	Medium Low	1	1	1	2	2
S Judd Pkwy SE	S Main St	Angier Rd	5	Medium Low	1	1	2	1	1
S Judd Pkwy SE	Holland Rd	N Main St	5	Medium Low	1	1	3	1	1
N Salem St	US 64 To N Salem St Ramp	Apex Pewy	5	Medium Low	1	1	1	2	1
Buck Jones Rd	Barclay Dr	South Valley Ct	5	Medium Low	1	1	2	3	2
St Marys St	W Peace St	Nichols Dr	5	Medium Low	1	1	2	1	3
St Marys St	Craig St	Glenwood Ave	5	Medium Low	1	1	2	1	2
St Marys St / Lassiter Mill Rd	Wedgedale Dr	May Ct	5	Medium Low	1	1	2	3	2
W Whitaker Mill Rd / E Whitaker Mill Rd	Mccarthy St	Reaves Dr	5	Medium Low	1	1	2	1	2
N Salem St / S Salem St	Templeton St	E Williams St / W Williams St	5	Medium Low	1	1	2	2	2
S Boylan Ave	W Lenoir St	Tate Dr	5	Medium Low	1	1	2	1	3
Halifax St	N Salisbury St / N Wilmington St	Cedar St	5	Medium Low	1	1	2	1	3
Dixie Trl	Friendly Dr / Hillsborough St	Lake Boone Trl	5	Medium Low	1	1	2	2	2
Dartmouth Rd	Main At North Hills St / Six Forks Rd	Windsor Pl	5	Medium Low	1	1	2	3	3
Dan Allen Dr	Hillsborough St	Fraternity Ct	5	Medium Low	1	1	2	3	2
Crabtree Blvd	N Raleigh Blvd	Timber Dr	5	Medium Low	1	1	2	1	2
White Oak Rd	White Oak Rd	Timber Dr E	5	Medium Low	1	1	2	2	1
Vandora Springs Rd	Seventh Ave / Foxwood Dr	W Garner Rd	5	Medium Low	1	1	3	2	2
White Oak Rd	Timber Dr E	Jones Sausage Rd / US 70 Hwy E	5	Medium Low	1	1	2	2	1
W South St	S Saunders St	S Dawson St	4	Medium Low	3	3	2	2	3
Knightdale Blvd	HINTON OAKS BLVD	I 540 WB	4	Medium Low	3	3	2	3	1

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Capital Blvd	Highwoods Blvd	I 440 WB	4	Medium Low	2	3	2	2	2
Height Ln	Capital Blvd	Ponderosa Service Rd	4	Medium Low	1	3	2	2	1
Star Rd	Star Rd	Edgar Ln	4	Medium Low	1	3	1	2	1
Glenwood Ave To I 540 Ramp	Glenwood Ave	Glenwood Ave To I 540 Ramp WB	4	Medium Low	1	3	2	2	1
Falls Of Neuse Rd	Tabriz Pt	Fonville Rd	4	Medium Low	1	3	1	2	1
I 440 EB	N Raleigh Blvd	I 440 Exit 12 Ramp EB	4	Medium Low	1	3	1	2	2
Knightdale Blvd	I 540 Ramp SB	HINTON OAKS BLVD	4	Medium Low	1	3	2	3	1
Fayetteville Rd	Gelder Dr	SHADY SUMMIT WAY	4	Medium Low	1	3	2	2	1
Capital Blvd	I 440 EB	Highwoods Blvd	4	Medium Low	1	3	1	2	2
Capital Blvd	Star Rd / Ponderosa Service Rd	Stickman St	4	Medium Low	1	3	2	2	1
Capital Blvd	Burlington Mills Rd	Durant Rd	4	Medium Low	1	3	1	2	1
US 64 Hwy W	Edinburgh Dr / Edinburgh South Dr	Tryon Rd / US 1 Hwy	4	Medium Low	1	3	1	2	2
Fayetteville Rd	Caddy Rd		4	Medium Low	1	3	2	2	1
Capital Blvd	Perry Creek Rd / Durant Rd		4	Medium Low	1	3	1	2	1
Capital Blvd	Stickman St	Star Rd	4	Medium Low	1	3	2	2	1
Chapel Hill Rd	Portrait Dr	NE Maynard Rd	4	Medium Low	3	2	1	3	1
NE Maynard Rd	Chapel Hill Rd	Sudbury Dr	4	Medium Low	3	2	1	3	1
Poole Rd	Hickory Hollow Ln / Maybrook Dr	S New Hope Rd	4	Medium Low	3	2	2	2	1
SE Maynard Rd	Ralph Dr	Wilshire Dr	4	Medium Low	3	2	2	3	2
Hammond Rd	I 40 Exit 299 Ramp WB	Hoke St	4	Medium Low	3	2	2	2	3
Perry Creek Rd / Durant Rd	Liston Dr / Filbin Creek Dr	Capital Hills Dr	4	Medium Low	3	2	2	2	1
S New Hope Rd	S Rogers Ln	Old Poole Rd	4	Medium Low	3	2	2	1	1
Tryon Rd	Hammond Rd	S Wilmington St	4	Medium Low	3	2	2	1	2
Farmwell Rd	Old Milburnie Rd	Charvoz Cir	4	Medium Low	3	2	2	3	1
Chapel Hill Rd	Chesterfield Dr	E Durham Rd	4	Medium Low	3	2	1	1	2
Martin Luther King Jr Blvd	Rock Quarry Rd	Poole Rd	4	Medium Low	3	2	1	2	1
N New Hope Rd	N New Hope Rd	New Bern Ave	4	Medium Low	3	2	1	2	2
Lake Boone Trl	Blue Ridge Rd	Wycliff Rd	4	Medium Low	3	2	2	2	3
N Tarboro St	Oakwood Ave	E Edenton St	4	Medium Low	3	2	2	2	3
Old Apex Rd	Falcone Pkwy	W Chatham St	4	Medium Low	3	2	1	2	2
Green Rd	New Hope Church Rd / Huntleigh Dr	E Millbrook Rd	4	Medium Low	3	2	2	2	2
Martin Luther King Jr Blvd	Peyton St	Martin Luther King Jr Blvd	4	Medium Low	3	2	1	2	1
Falls Of Neuse Rd	Pacific Dr / Bland Rd	Sandy Forks Rd	4	Medium Low	3	2	2	2	2
Spring Forest Rd / Dixie Forest Rd	Quail Ridge Rd	Old Wake Forest Rd	4	Medium Low	3	2	1	1	1
Corporation Pkwy	New Bern Ave	Columbus Club Dr	4	Medium Low	3	2	1	2	2
Fox Rd	Werribee Dr / Jeffreys Creek Ln	Louisburg Rd	4	Medium Low	3	2	2	2	1
New Bern Ave	Beacon Lake Dr	Freedom Dr	4	Medium Low	3	2	2	2	2
Knightdale Blvd	Old Milburnie Rd	Westover Dr	4	Medium Low	3	2	3	3	1
S New Hope Rd	Poole Rd	S Rogers Ln	4	Medium Low	3	2	2	1	1
Poole Rd	S New Hope Rd	Heritage Manor Dr	4	Medium Low	3	2	2	2	1
Western Blvd	Jones Franklin Rd	Hillsborough St	4	Medium Low	3	2	3	3	2
Rock Quarry Rd	Interlock Dr		4	Medium Low	3	2	1	2	1
Hammond Rd	Hoke St / S Blount St	I 40 WB	4	Medium Low	3	2	2	2	3
US 70 Hwy W	Yeargan Rd	Timber Dr	4	Medium Low	3	2	3	1	2
S Wilmington St	Mechanical Blvd	Fayetteville Rd	4	Medium Low	3	2	2	3	2
Knightdale Blvd	Westover Dr	Old Milburnie Rd	4	Medium Low	3	2	3	3	1
NC 55 Hwy	Good Hope Church Rd	Parkside Green St	4	Medium Low	2	2	1	2	1
Chapel Hill Rd	Mccrimmon Pkwy	Airport Blvd	4	Medium Low	2	2	2	1	2
W Millbrook Rd	Lead Mine Rd	Creedmoor Rd	4	Medium Low	2	2	2	1	2
NW Maynard Rd	High House Rd	Weather Ridge Ln	4	Medium Low	2	2	2	3	2
E Chatham St	E Circle Dr	N Academy St	4	Medium Low	2	2	2	1	2
Davis Dr	Mccrimmon Pkwy	Lattner Ct	4	Medium Low	2	2	1	2	1
Old Apex Rd	High House Rd	Falcone Pkwy	4	Medium Low	2	2	1	2	2
Sumner Blvd	Melville Dr	Triangle Town Blvd	4	Medium Low	2	2	2	2	2
N Harrison Ave	NW Cary Pkwy	Chapel Hill Rd	4	Medium Low	2	2	2	2	1
N Smithfield Rd	Knightdale Blvd	Mcknight Dr	4	Medium Low	2	2	2	3	1
N Harrison Ave	NE Maynard Rd / NW Maynard Rd	Reedy Creek Rd	4	Medium Low	2	2	2	2	1
Mccrimmon Pkwy	Madison Heights Way	Lake Grove Blvd	4	Medium Low	2	2	2	2	1
Glenwood Ave	Hertz Dr	Barrowood Dr	4	Medium Low	2	2	2	2	2
Knightdale Blvd	Crossover	N Smithfield Rd	4	Medium Low	2	2	2	3	1

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Route	From	To	Suitability	Category	Comm. Of Concern	Feasibility	Full Time Suit.	TSP Suit.	Nonmotor. Propensity
High House Rd	Cavendish Dr	Old Apex Rd	4	Medium Low	2	2	2	3	1
Rock Quarry Rd	Old Williams Rd	New Birch Dr	4	Medium Low	2	2	1	2	1
Buffaloe Rd	N New Hope Rd	Bison Hill Ln	4	Medium Low	2	2	2	1	1
S NC 55 Hwy	Jicarilla Ln	Clayton Rd	4	Medium Low	1	2	1	3	1
N Main St	N Judd Pkwy NE	Lakestone Commons Ave	4	Medium Low	1	2	2	3	1
S NC 55 Hwy	N Main St	NC 42 Hwy	4	Medium Low	1	2	1	3	1
E Williams St	S Tunstall Ave	S Salem St	4	Medium Low	1	2	1	2	2
NC 55 Hwy	Jenks Rd / Old Jenks Rd	Catlin Rd / Parkscene Ln	4	Medium Low	1	2	1	2	1
NC 55 Hwy	Green Level West Rd / High House Rd	Connemara Dr / Highfield Ave	4	Medium Low	1	2	1	2	1
Chapel Hill Rd	S Miami Blvd	NC 540 Ramp	4	Medium Low	1	2	2	2	2
Gb Alford Hwy	Crossover	Green Oaks Pkwy	4	Medium Low	1	2	2	3	1
Chapel Hill Rd	NC 540 Ramp	Chapel Hill Rd	4	Medium Low	1	2	1	2	2
NC 55 Hwy	Alston Village Ln	Carpenter Fire Station Rd	4	Medium Low	1	2	1	2	1
E Williams St	E Williams St	Lufkin Rd	4	Medium Low	1	2	2	2	1
Holly Springs Rd	Sunset Fairways Dr	Middle Creek Farm Rd	4	Medium Low	1	2	2	3	1
Sunset Lake Rd	Edwards Dr	Clyde Dr	4	Medium Low	1	2	2	3	1
Walnut St	Meeting St	Macedonia Rd / Crossroads Manor Ct	4	Medium Low	1	2	1	3	2
Buck Jones Rd	Buck Jones Rd	Buck Jones Rd	4	Medium Low	1	2	2	3	2
Piney Plains Rd	Dillard Dr	Chaffin Way	4	Medium Low	1	2	2	2	2
Durant Rd	Deponie Dr	Falls Of Neuse Rd	4	Medium Low	1	2	2	2	1
E Millbrook Rd	Flint Ridge Pl	Six Forks Rd	4	Medium Low	1	2	2	2	2
Rogers Rd	S Main St	Heritage Branch Rd	4	Medium Low	1	2	2	1	1
Timber Dr	Aversboro Rd	Chapwith Rd	4	Medium Low	1	2	2	2	1
Creedmoor Rd / Edwards Mill Rd	Manor Park Dr	Carriage Dr	4	Medium Low	1	2	3	3	1
Airport Blvd	Mccrimmon Pkwy	Perimeter Park Dr	4	Medium Low	1	2	1	1	3
Hillsborough St	Burton Ave / Western Blvd	Bashford Rd	4	Medium Low	1	2	1	1	2
E Whitaker Mill Rd	Reaves Dr	Wake Forest Rd	4	Medium Low	1	2	2	1	2
SW Cary Pkwy	High House Rd	Marquette Dr	4	Medium Low	1	2	2	2	2
SW Cary Pkwy	Inverleigh Dr	Laura Duncan Rd	4	Medium Low	1	2	1	2	1
Yonkers Rd	N Raleigh Blvd	I 440 Exit 12 Ramp EB	4	Medium Low	1	2	1	2	2
Weston Pkwy	Renaissance Park Pl	Norwell Blvd	4	Medium Low	1	2	2	2	2
W Hargett St	Fayetteville St	S West St	4	Medium Low	1	2	3	2	3
Timber Dr E	White Oak Rd	Adeline Way / Ashton Village Ln	4	Medium Low	1	2	2	2	1
S Harrington St	Hillsborough St	W Martin St	4	Medium Low	1	2	2	1	3
Falls Of Neuse Rd	Wide River Dr	Crossover	4	Medium Low	1	2	1	2	1
Falls Of Neuse Rd	Crossover	Falls Of Neuse Rd	4	Medium Low	1	2	1	2	1
Crossroads Blvd	Caitboo Ave	Royal Birkdale Dr	4	Medium Low	1	2	2	1	2
Cates Ave	Pullen Rd	Morrill Dr	4	Medium Low	1	2	2	3	3
T W Alexander Dr	Fellowship Dr	Little Brier Creek Ln	4	Medium Low	1	2	1	2	1
Lynn Rd	Genford Ct	Six Forks Rd	4	Medium Low	1	2	2	2	1
NW Cary Pkwy	Sheldon Dr	Chapel Hill Rd	4	Medium Low	1	2	1	2	2
Tryon Rd	Keisler Dr / New Waverly Pl	Ashville Ave	4	Medium Low	1	2	1	2	2
SE Cary Pkwy / SW Cary Pkwy	High Meadow Dr	Cork Harbor Dr	4	Medium Low	1	2	1	2	2
SW Cary Pkwy	Laura Duncan Rd	Bebington Dr	4	Medium Low	1	2	1	2	1
SW Cary Pkwy	Muir Woods Dr	High House Rd	4	Medium Low	1	2	1	2	2
Gb Alford Hwy	W Ballentine St	Crossover	4	Medium Low	1	2	2	3	1
US 70 Hwy W	Timber Dr	Loop Rd	4	Medium Low	1	2	3	1	2
N Main St	Ideal Ln / Mill Creek Dr	Meadow Dr	4	Medium Low	1	2	2	3	1
N Main St / Fayetteville Rd	Lake Wheeler Rd	Crossover	4	Medium Low	1	2	2	3	1
Green Level West Rd / High House Rd	Joshua Tree Ct	Sir Walker Ln / Cranborne Ln	4	Medium Low	1	2	2	2	1
Old Holly Springs Apex Rd	NC 540 Hwy NB	Woods Creek Rd	4	Medium Low	1	2	1	3	1
US 64 Hwy W	Knollwood Dr	Gregson Dr	4	Medium Low	1	2	1	2	2
Dr Calvin Jones Hwy	S Franklin St	S Main St	4	Medium Low	1	2	3	1	1
Dr Calvin Jones Hwy	Capital Blvd Ramp	Wakefield Plantation Dr	4	Medium Low	1	2	3	1	1
Six Forks Rd	Strickland Rd	Waterford Park Ln / Featherstone Dr	4	Medium Low	1	2	2	2	2
Capital Blvd	Crossover	Wake Forest Rd	4	Medium Low	1	2	1	2	2
Fayetteville Rd / N Main St	Scott Rd	Crossover	4	Medium Low	1	2	2	3	1
N Main St	Meadow Dr	N Main St	4	Medium Low	1	2	2	3	1
Creedmoor Rd	Morgans Way	Bandford Way	4	Medium Low	1	2	2	2	1
New Bern Ave	Raleigh Beach Rd	N New Hope Rd	4	Medium Low	1	2	3	3	1

Segment Info			RED Lanes	Suitability	Detailed Differentiators		Implementation Guidance		
Route	**From**	**To**	**Suitability**	**Category**	**Comm. Of Concern**	**Feasibility**	**Full Time Suit.**	**TSP Suit.**	**Nonmotor. Propensity**
Dr Calvin Jones Hwy	Wakefield Plantation Dr	Capital Blvd Ramp	4	Medium Low	1	2	3	1	1
Dr Calvin Jones Hwy	S Main St	S Franklin St	4	Medium Low	1	2	3	1	1
US 64 Hwy W	US 1 Hwy	Chalon Dr	4	Medium Low	1	2	1	2	2
Creedmoor Rd	Morgans Way	Brennan Dr	4	Medium Low	1	2	2	2	1
Sanderford Rd	Rock Quarry Rd	Evers Dr	4	Medium Low	3	1	2	3	1
E Chatham St	Soccer Park Dr	NE Maynard Rd / SE Maynard Rd	4	Medium Low	3	1	1	1	2
Rush St	Ileagnes Rd / S Wilmington St	Hammond Rd	4	Medium Low	3	1	2	1	1
Rush St / Cross Link Rd	Disco Ln	Herndon Village Way / BLUEGROVE RD	4	Medium Low	3	1	2	1	1
Garner Rd	Peterson St	Bragg St	4	Medium Low	3	1	1	2	3
Oakwood Ave	Watauga St	Oakwood Ave / N Raleigh Blvd	4	Medium Low	3	1	2	2	3
Seabrook Rd	Evers Dr	Sanderford Rd	4	Medium Low	3	1	2	3	1
Method Rd	Beryl Rd	Stedman Dr	4	Medium Low	3	1	2	1	2
Maywood Ave	Fayetteville St	S Saunders St	4	Medium Low	3	1	3	3	3
E Lenoir St	S Bloodworth St	Rock Quarry Rd	4	Medium Low	3	1	2	1	3
Beryl Rd	Pylon Dr	Blue Ridge Rd	4	Medium Low	3	1	2	2	3
CALVARY DR	Capital Blvd	Green Rd	4	Medium Low	3	1	2	1	2
Calvary Dr	Green Rd		4	Medium Low	3	1	2	1	2
Hardimont Rd	Babock Ct	Wake Forest Rd	4	Medium Low	3	1	3	3	3
W Garner Rd	Garner Rd	Vandora Springs Rd	4	Medium Low	2	1	2	2	1
Kit Creek Rd	NC 55 Hwy	Louis Stephens Dr	4	Medium Low	2	1	2	1	1
Nowell Rd	Trinity Rd	Sandwell Ln	4	Medium Low	2	1	2	1	2
W Chatham St	Old Apex Rd	High House Rd	4	Medium Low	2	1	2	3	2
Clark Ave	Oberlin Rd	Brooks Ave	4	Medium Low	2	1	2	1	3
Jones Franklin Rd	Barringer Dr	Jones Franklin Rd	4	Medium Low	2	1	1	1	2
Wendell Blvd	Hanor Ln / Liles Dean Rd	Industrial Dr	4	Medium Low	2	1	2	2	1
S Main St / Louisburg Rd	Redford Place Dr / Rogers Rd	E Young St	4	Medium Low	1	1	2	1	1
Trinity Rd / Trenton Rd	Chapel Hill Rd	Trinity Rd	4	Medium Low	1	1	2	3	2
Blue Ridge Rd	Glenwood Ave	Holly Ln	4	Medium Low	1	1	2	3	2
Trawick Rd	Marsh Creek Rd	Dogwood Dr	4	Medium Low	1	1	2	1	2
Barwell Rd	Chatmoss Dr	Poole Rd	4	Medium Low	1	1	2	2	1
S Judd Pkwy SE	Angier Rd	Holland Rd	4	Medium Low	1	1	2	1	2
St Marys St	Nichols Dr	Craig St	4	Medium Low	1	1	2	1	2
N Boundary St / Brookside Dr	Elm St	Edmund St	4	Medium Low	1	1	2	1	3
Fairview Rd	Fairview Rd	W Whitaker Mill Rd	4	Medium Low	1	1	2	1	2
Faircloth St	Hillsborough St	Wade Ave	4	Medium Low	1	1	2	1	2
S East St	E Hargett St	E South St	4	Medium Low	1	1	1	1	3
Sandy Forks Rd	Lynn Rd	Shanda Dr	4	Medium Low	1	1	2	1	2
North Hills Dr	ROYAL HILL CT / Lead Mine Rd	Old Village Rd	4	Medium Low	1	1	2	3	2
Dartmouth Rd	Windsor Pl	Converse Dr	4	Medium Low	1	1	2	3	3
Lineberry Dr	Mountain Mist Ct / Crestscene Trl	Canine Tech Way / Trailwood Dr	4	Medium Low	1	1	2	2	1
Durham Rd	Wake Union Church Rd	Retail Dr	4	Medium Low	1	1	2	1	1
Ebenezer Church Rd	Glenwood Ave	Spring Breeze Dr	4	Medium Low	1	1	2	2	2
W North Ave / E North Ave	E Cedar Ave	N Main St	4	Medium Low	1	1	2	1	1
Louisburg Rd	Mitchell Mill Rd	Forestville Rd	4	Medium Low	1	1	2	2	1
Louisburg Rd	Forestville Rd	Mitchell Mill Rd / Ligon Mill Rd	4	Medium Low	1	1	2	2	1
Capital Blvd To Fairview Ramp WB	Capital Blvd	Fairview Rd	3	Low	1	3	1	1	2
Timber Dr	Chapwith Rd	White Oak Rd	3	Low	1	3	2	2	1
I 540 Exit 4 Ramp WB	Glenwood Ave Ramp	Glenwood Ave	3	Low	1	3	2	2	1
Glenwood Ave Ramp	I 540 Exit 4 Ramp EB	Lumley Rd	3	Low	1	3	2	2	2
Glenwood Ave Ramp	I 540 Exit 4 Ramp EB	Glenwood Ave To I 540 Ramp EB	3	Low	1	3	2	2	2
Glenwood Ave To I 540 Ramp EB	Glenwood Ave To I 540 Ramp WB	I 540 Exit 4 Ramp EB	3	Low	1	3	2	2	1
Falls Of Neuse Rd	Kings Grant Dr / Whittington Dr	Tabriz Pt	3	Low	1	3	1	2	1
Glenwood Ave To I 540 Ramp WB	Glenwood Ave Ramp	I 540 WB	3	Low	1	3	2	2	1
Glenwood Ave	Glenwood Ave To I 540 Ramp	I 540 Exit 4 Ramp EB	3	Low	1	3	2	2	2
Glenwood Ave	Fleetwood Dr	Hertz Dr	3	Low	1	3	2	2	1
Capital Blvd	Wade Ave	Crossover	3	Low	1	3	1	2	2
Capital Blvd	Stickman St	Burlington Mills Rd	3	Low	1	3	1	2	1
US 1 Hwy	Tryon Rd	US 64 Hwy W	3	Low	1	3	2	2	1
I 40 WB	US 70 Hwy E	US 70 Hwy E / I 40 WB	3	Low	1	3	2	2	1
Glenwood Ave	Hilburn Dr	Westborough Dr / Pinecrest Rd	3	Low	1	3	2	2	1

Segment Info			RED Lanes	Suitability	Detailed Differentiators		Implementation Guidance		
Route	**From**	**To**	**Suitability**	**Category**	**Comm. Of Concern**	**Feasibility**	**Full Time Suit.**	**TSP Suit.**	**Nonmotor. Propensity**
Glenwood Ave	Glenwood Ave Ramp	I 540 Exit 4 Ramp WB	3	Low	1	3	2	2	2
Capital Blvd	Capital Blvd To Fairview Ramp WB / Fairview	Wade Ave To Capital Blvd Ramp SB	3	Low	1	3	1	2	2
Capital Blvd		Stickman St	3	Low	1	3	1	2	1
NW Maynard Rd	Sudbury Dr	NW Maynard Rd	3	Low	3	2	1	3	1
Tryon Rd	Junction Blvd	S Wilmington St	3	Low	3	2	1	2	2
Blue Ridge Rd	Faber Dr	Beryl Rd	3	Low	3	2	1	3	2
Centennial Pkwy	Champion Ct / Avent Ferry Rd	Oval Dr	3	Low	3	2	1	3	2
Walnut St	Kildaire Farm Rd	Cary Towne Blvd	3	Low	3	2	1	3	2
Sunnybrook Rd	Carl Sandburg Ct	Poole Rd	3	Low	3	2	1	2	3
Atlantic Ave	E Millbrook Rd	Forest Oaks Dr	3	Low	3	2	1	1	3
Yonkers Rd	New Bern Ave	Kelley Austin Dr / New Bern Ave	3	Low	3	2	2	2	1
S Wilmington Service Rd	Tryon Rd	Mechanical Blvd	3	Low	3	2	2	3	2
High House Rd	W Chatham St	Old Apex Rd / High House Rd	3	Low	3	2	2	3	2
Sunnybrook Rd	Poole Rd	Carl Sandburg Ct	3	Low	3	2	1	2	3
Martin Luther King Jr Blvd	Martin Luther King Jr Blvd	Peyton St	3	Low	3	2	1	2	1
Rock Quarry Rd	Poole Farm Ln	Battle Bridge Rd	3	Low	3	2	1	1	1
Knightdale Blvd	Maplewood Dr	Mcknight Dr	3	Low	3	2	2	2	2
Knightdale Blvd	I 540 WB	Westover Dr	3	Low	3	2	2	3	1
NC 55 Hwy	Parkside Green St	NC 55 Hwy	3	Low	2	2	1	2	1
Chapel Hill Rd	Airport Blvd	Johnnie Robertson St	3	Low	2	2	1	1	2
Chapel Hill Rd	Linda Dr	Portrait Dr	3	Low	2	2	1	1	2
Chapel Hill Rd	Nowell Rd	Hooker Dr	3	Low	2	2	1	2	2
Trinity Rd	Trinity Rd	Sunday Dr	3	Low	2	2	1	2	2
Trinity Rd	PETER KARMANOS JR DR / Youth Center Dr	Blue Ridge Rd	3	Low	2	2	1	3	3
Morrisville Carpenter Rd	Old Savannah Dr	Davis Dr	3	Low	2	2	1	2	1
Edwards Mill Rd	Trinity Rd	Edwards Mill Rd	3	Low	2	2	1	3	3
Hillsborough St	Chapel Hill Rd	Western Blvd	3	Low	2	2	1	2	3
Davis Dr	Davis Dr	Kit Creek Rd	3	Low	2	2	1	2	1
Old Apex Rd	SW Maynard Rd / NW Maynard Rd	High House Rd	3	Low	2	2	1	2	1
SE Cary Pkwy	Cary Pkwy To US 1 Ramp SB	Tryon Rd	3	Low	2	2	1	2	1
Edwards Mill Rd	Edwards Mill Rd	Trinity Rd	3	Low	2	2	1	3	3
S Franklin St	E Holding Ave	Dr Calvin Jones Hwy	3	Low	2	2	2	1	1
Triangle Town Blvd	Sumner Blvd	Old Wake Forest Rd	3	Low	2	2	2	2	2
N Salem St To US 64 Ramp WB	Davis Dr	US 64 Hwy W	3	Low	2	2	1	2	1
Mccrimmon Pkwy	Lake Grove Blvd	Town Hall Dr	3	Low	2	2	1	2	1
SE Cary Pkwy	Tryon Rd	US 1 Exit Ramp SB	3	Low	2	2	1	2	1
Knightdale Blvd	N Smithfield Rd	Mcknight Dr / Maplewood Dr	3	Low	2	2	2	2	2
Wendell Blvd	US 64 Hwy WB	Wendell Blvd	3	Low	2	2	2	2	1
Wendell Blvd	Liles Dean Rd	Hanor Ln / Liles Dean Rd	3	Low	2	2	2	2	1
Knightdale Blvd	Wendell Blvd	US 64 Ramp WB	3	Low	2	2	2	2	1
US 64 Hwy W	N Salem St	W Williams St To US 64 Ramp WB	3	Low	2	2	1	2	2
S Main St	Selsey Dr	Spring Park Rd	3	Low	1	2	2	2	1
S NC 55 Hwy	Lagenaria Dr	Saunders Rd	3	Low	1	2	1	3	1
S NC 55 Hwy	Hazelton Ln	Terra Mobile Estates Cir	3	Low	1	2	1	3	1
S NC 55 Hwy	NC 42 Hwy	Terra Mobile Estates Cir	3	Low	1	2	1	3	1
W Williams St	S Salem St	Apex Pewy	3	Low	1	2	1	2	2
W Williams St	US 64 Ramp EB	Jenks Rd / Old Jenks Rd	3	Low	1	2	1	2	2
NC 55 Hwy	Connemara Dr / Highfield Ave	Glendon Way	3	Low	1	2	1	2	1
Chapel Hill Rd	Chapel Hill Rd	Mccrimmon Pkwy	3	Low	1	2	1	1	3
NC 55 Hwy	NC 55 Hwy	Alston Village Ln	3	Low	1	2	1	2	1
Aviation Pkwy	Airport Blvd	National Guard Dr	3	Low	1	2	2	3	1
Aviation Pkwy	Evans Rd	Morrisville Carpenter Rd / Chapel Hill Rd	3	Low	1	2	1	2	2
Holly Springs Rd	Sunset Lake Rd	Sunset Fairways Dr	3	Low	1	2	1	3	1
Holly Springs Rd	Middle Creek Farm Rd	Grassy Meadow Rd / Flint Point Ln	3	Low	1	2	1	3	1
W Holly Springs Rd	N Main St	Gb Alford Hwy	3	Low	1	2	1	3	1
Holly Springs New Hill Rd	Old Holly Springs Apex Rd	Green Oaks Pkwy	3	Low	1	2	1	3	1
Sunset Lake Rd		Turner Dr	3	Low	1	2	1	3	1
Sunset Lake Rd	Clyde Dr	Holly Springs Rd	3	Low	1	2	1	3	1
Walnut St	Cary Towne Blvd	SE Maynard Rd	3	Low	1	2	1	3	2
Walnut St	Macedonia Rd / Crossroads Manor Ct	Holly Springs Rd / Tryon Rd	3	Low	1	2	1	1	2

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Route	From	To	Suitability	Category	Comm. Of Concern	Feasibility	Full Time Suit.	TSP Suit.	Nonmotor. Propensity
Piney Plains Rd	Chaffin Way	Tryon Rd	3	Low	1	2	1	2	2
Old Raleigh Rd	Laura Duncan Rd	Lake Pine Dr	3	Low	1	2	1	2	1
Old Apex Rd	W Chatham St	SW Maynard Rd / NW Maynard Rd	3	Low	1	2	1	2	1
Davis Dr	Kit Creek Rd	Davis Dr	3	Low	1	2	1	2	1
Durant Rd	Capital Hills Dr	Deponie Dr	3	Low	1	2	2	2	1
Airport Blvd	I 40 Ramp WB	Aviation Pkwy	3	Low	1	2	2	3	1
Chapel Hill Rd	E Durham Rd	NE Maynard Rd	3	Low	1	2	1	3	2
Brier Creek Pkwy	Glenwood Ave	Iverness Dr	3	Low	1	2	2	1	1
Acc Blvd	Brier Creek Pkwy	INSPIRE DR	3	Low	1	2	2	1	1
Jones Sausage Rd	US 70 Hwy E	E Garner Rd	3	Low	1	2	1	2	1
Cary Pkwy	Village Market Pl	Sheldon Dr	3	Low	1	2	1	2	2
Tryon Rd	US 64 Hwy W / US 1 Hwy	Tryon Rd	3	Low	1	2	1	2	2
SW Cary Pkwy	Marquette Dr	Inverleigh Dr	3	Low	1	2	1	2	1
SW Cary Pkwy	Laura Duncan Rd	Kildaire Farm Rd	3	Low	1	2	1	2	1
Airport Blvd	Aviation Pkwy	Pleasant Grove Church Rd	3	Low	1	2	2	3	1
Weston Pkwy	Norwell Blvd	Laurel Commons Way	3	Low	1	2	1	2	2
Weston Pkwy	Weston Estates Way / Sheldon Dr	Summit Ridge Loop	3	Low	1	2	1	1	2
Perimeter Park Dr	Airport Blvd	Mccrimmon Pkwy	3	Low	1	2	1	2	3
Lake Boone Trl	Dixie Trl	Ridge Rd / Lake Boone Trl	3	Low	1	2	1	2	2
John Brantley Blvd	Airport Blvd	Aviation Ramp WB	3	Low	1	2	2	3	1
Green Oaks Pkwy	Gb Alford Hwy	Premier Dr	3	Low	1	2	1	3	1
Falls Of Neuse Rd	Crossover	Grove Ridge Rd	3	Low	1	2	1	2	1
Falls Of Neuse Rd	Forest Pines Dr	Crossover	3	Low	1	2	1	2	1
Crossroads Blvd	Royal Birkdale Dr	Crossroads Crest Way / Jones Franklin Rd	3	Low	1	2	1	1	2
Carrington Mill Blvd	Chapel Hill Rd	Paramount Pkwy	3	Low	1	2	1	2	2
Airport Blvd	John Brantley Blvd	Aviation Pkwy	3	Low	1	2	2	3	1
NW Cary Pkwy	N Harrison Ave	NW Cary Pkwy	3	Low	1	2	2	1	2
US 64 To N Salem St Ramp	US 64 Hwy W	N Salem St	3	Low	1	2	1	2	1
Airport Blvd To Aviation Ramp EB	Airport Blvd	Aviation Ramp EB	3	Low	1	2	2	3	1
Airport Blvd To Aviation Ramp EB	Airport Blvd	Aviation Pkwy	3	Low	1	2	2	3	1
Glenwood Ave Ramp	Glenwood Ave	Westgate Rd	3	Low	1	2	2	2	2
Glenwood Ave Ramp	Westgate Rd	Glenwood Ave To I 540 Ramp EB	3	Low	1	2	2	2	2
I 540 Exit 4 Ramp EB	Lumley Rd	Glenwood Ave	3	Low	1	2	2	2	2
I 540 Exit 4 Ramp EB	Glenwood Ave To I 540 Ramp WB	Glenwood Ave Ramp	3	Low	1	2	2	1	1
Glenwood Ave Ramp	Glenwood Ave To I 540 Ramp WB	I 540 Exit 4 Ramp WB	3	Low	1	2	2	2	1
Glenwood Ave Ramp	Glenwood Ave	I 540 Exit 4 Ramp WB	3	Low	1	2	2	2	1
Glenwood Ave Ramp	Glenwood Ave Ramp	I 540 Exit 4 Ramp EB	3	Low	1	2	2	2	1
Airport Blvd To Aviation Ramp EB	Airport Blvd To Aviation Ramp EB	Pleasant Grove Church Rd	3	Low	1	2	2	3	1
Capital Blvd Ramp	Capital Blvd Ramp	Capital Blvd	3	Low	1	2	2	2	1
Capital Blvd Ramp	Dr Calvin Jones Hwy	Capital Blvd Ramp	3	Low	1	2	1	2	1
John Brantley Blvd	Aviation To John Brantley Ramp	Aviation Pkwy	3	Low	1	2	2	3	1
Acc Blvd	T W Alexander Dr	Brier Creek Pkwy	3	Low	1	2	1	2	1
I 540 Exit 4 Ramp WB	Glenwood Ave To I 540 Ramp EB	Glenwood Ave Ramp	3	Low	1	2	2	2	1
Aversboro Rd	Aversboro Rd	Timber Dr	3	Low	1	2	2	1	2
Capital Blvd Ramp	Capital Blvd	Capital Blvd Ramp	3	Low	1	2	2	2	1
Capital Blvd Ramp	Capital Blvd Ramp	Dr Calvin Jones Hwy	3	Low	1	2	1	2	1
Jones Franklin Rd	FRANKLIN SPRING LN	BATOUL LN	3	Low	1	2	1	1	2
Jones Franklin Rd	I 40 EB	Denise Dr	3	Low	1	2	1	2	1
Strickland Rd	Harvest Oaks Dr	Kings Arms Way / Colonnade Center Dr	3	Low	1	2	1	1	2
Lynn Rd	Hearthridge Ct / North Hills Dr	Genford Ct	3	Low	1	2	2	2	1
Dillard Dr	Jones Franklin Rd	Piney Plains Rd	3	Low	1	2	1	2	2
Tryon Rd	Wellingborough Dr	Keisler Dr / New Waverly Pl	3	Low	1	2	1	2	1
Tryon Rd / US 64 Hwy W	Ashville Ave	US 1 Hwy	3	Low	1	2	1	2	1
NW Cary Pkwy	Silverrock Ct / Norwell Blvd	N Harrison Ave	3	Low	1	2	2	1	2
T W Alexander Dr	Little Brier Creek Ln	Fellowship Dr	3	Low	1	2	1	2	1
Lynn Rd	Grove Barton Rd	Glenwood Ave	3	Low	1	2	2	1	1
SW Cary Pkwy	Cork Harbor Dr	Laura Duncan Rd	3	Low	1	2	1	2	1
SW Cary Pkwy	Bebington Dr	Muir Woods Dr	3	Low	1	2	1	2	1
US 70 Hwy E	Jones Sausage Rd	US 70 Hwy E / I 40 EB	3	Low	1	2	2	2	1
Knightdale Blvd	Westover Dr	I 540 Ramp SB	3	Low	1	2	2	3	1

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Route	From	To	Suitability	Category	Comm. Of Concern	Feasibility	Full Time Suit.	TSP Suit.	Nonmotor. Propensity
Capital Blvd	Wake Union Church Rd	Capital Blvd To Durham Rd Ramp	3	Low	1	2	2	1	1
Capital Blvd	Dr Calvin Jones Hwy	Capital Blvd Ramp	3	Low	1	2	2	2	1
Capital Blvd	Crossover / Popes Creek Dr	Falls Of Neuse Rd	3	Low	1	2	2	2	1
Old Holly Springs Apex Rd	Prince Dead End Rd	NC 540 Hwy NB	3	Low	1	2	2	3	1
Old Holly Springs Apex Rd	Forest Haven Dr	New Hill Rd	3	Low	1	2	1	3	1
Western Blvd	Burton Ave / Hillsborough St	Jones Franklin Rd	3	Low	1	2	1	1	2
Aviation Pkwy	National Guard Dr	Airport Blvd To Aviation Ramp WB	3	Low	1	2	2	3	1
US 64 Hwy W	W Williams St	Knollwood Dr	3	Low	1	2	1	2	1
US 70 Hwy E	I 40 WB	Jones Sausage Rd	3	Low	1	2	2	2	1
Six Forks Rd	Lead Mine Rd	Strickland Rd	3	Low	1	2	1	1	2
Six Forks Rd	Waterford Park Ln / Featherstone Dr	Sawmill Rd / Mourning Dove Rd	3	Low	1	2	1	2	2
Capital Blvd	Capital Blvd Ramp	Dr Calvin Jones Hwy	3	Low	1	2	2	2	1
US 64 Hwy W	Chalon Dr	US 64 To N Salem St Ramp	3	Low	1	2	1	2	1
E Broad St / N Broad St	Stewart St	N Judd Pkwy NE	3	Low	3	1	1	3	2
Marsh Creek Rd	Trawick Rd	N New Hope Rd	3	Low	3	1	2	1	1
Cross Link Rd	Herndon Village Way / BLUEGROVE RD	Seabrook Rd	3	Low	3	1	2	3	1
Cross Link Rd	Dandridge Dr	Platinum Ave / Hadley Rd	3	Low	3	1	1	1	1
Lake Boone Trl / Ridge Rd	Thomas Rd	Wade Ave	3	Low	3	1	2	1	2
Carolina Pines Ave	Lake Wheeler Rd	S Saunders St	3	Low	3	1	2	2	1
Glascock St	N Raleigh Blvd	Culpepper Ln	3	Low	3	1	1	2	1
Donald Ross Dr / N Peartree Ln	Kidd Rd	Milburnie Rd	3	Low	3	1	1	1	3
Varsity Dr	Faucette Dr	Avent Ferry Rd	3	Low	3	1	1	3	2
Pleasant Valley Rd	W Millbrook Rd	Duraleigh Rd	3	Low	3	1	2	1	2
Method Rd	Stedman Dr	Kent Rd / Western Blvd	3	Low	3	1	2	3	2
Main Campus Dr	Varsity Dr	Campus Shore Dr	3	Low	3	1	1	3	2
Holston Ln	Sunnybrook Rd	Merrell Dr / Calumet Dr	3	Low	3	1	1	2	3
Hollenden Dr	N New Hope Rd	Spring Forest Rd	3	Low	3	1	2	1	2
Fraternity Ct	GREEK VILLAGE DR	Varsity Dr	3	Low	3	1	1	3	2
E Davie St	S Bloodworth St	Rock Quarry Rd	3	Low	3	1	1	3	3
E Hargett St	S Bloodworth St	Lincoln Ct	3	Low	3	1	1	1	3
E Martin St	S Bloodworth St	S Tarboro St	3	Low	3	1	1	1	3
Calumet Dr	Sunnybrook Rd	Merrell Dr / Holston Ln	3	Low	3	1	1	2	3
Bragg St	S Blount St	Holmes St	3	Low	3	1	2	1	3
Mechanical Blvd	Timber Dr / Hammond Rd	Garner Station Blvd / Fayetteville Rd	3	Low	3	1	2	1	2
Center St	Keith St	N Salem St	3	Low	3	1	1	2	2
Kit Creek Rd	Louis Stephens Dr	Davis Dr	3	Low	2	1	1	2	1
N Salem St	Salem Church Rd	US 64 To N Salem St Ramp	3	Low	2	1	1	2	1
Buck Jones Rd	Jones Franklin Rd	Barclay Dr	3	Low	2	1	2	3	2
N Boundary St	N Person St	Elm St	3	Low	2	1	1	1	3
Oakwood Ave	N Person St	Watauga St	3	Low	2	1	1	2	3
S White St	Elm Ave	E Holding Ave	3	Low	2	1	2	1	1
Poplar St	N Blount St	Courtland Dr / Mordecai Dr	3	Low	2	1	2	1	3
N East St	New Bern Ave	Polk St	3	Low	2	1	1	1	3
E Holding Ave	S Main St	Deacon Ridge St	3	Low	2	1	2	1	1
E Lane St	N Person St	Linden Ave	3	Low	2	1	2	2	3
Kit Creek Rd	Davis Dr	Kit Creek Rd	3	Low	2	1	1	2	1
E Roosevelt Ave / Wait Ave	Front St	N Allen Rd / S Allen Rd	3	Low	2	1	2	1	1
E JUNIPER AVE	Sixth St	N White St	3	Low	2	1	2	1	1
S Main St	Dr Calvin Jones Hwy	Elm Ave	3	Low	1	1	1	2	1
Front St	E Roosevelt Ave	W Chestnut Ave / E Chestnut Ave	3	Low	1	1	2	1	1
S Main St	Burlington Mills Rd	Redford Place Dr / Rogers Rd	3	Low	1	1	1	2	1
W Garner Rd / E Garner Rd	Johnson St	New Rand Rd	3	Low	1	1	1	2	1
Slater Rd	Sorrell Grove Church Rd	Carrington Mill Blvd	3	Low	1	1	2	1	2
Blue Ridge Rd	Holly Ln	Duraleigh Rd	3	Low	1	1	2	3	3
Stadium Dr	Stadium Dr	N Wingate St / W North Ave	3	Low	1	1	2	1	1
Wake Union Church Rd	Agora Dr / Capital Blvd	Durham Rd	3	Low	1	1	2	1	1
Barwell Rd	Berkeley Lake Rd / Neals Creek Dr	Chatmoss Dr	3	Low	1	1	2	2	1
Raven Ridge Rd	Raven Ridge Rd	Anson Grove Ln / Durant Rd	3	Low	1	1	2	1	1
S Academy St / N Academy St	Waldo St	N Academy St / Chapel Hill Rd	3	Low	1	1	2	2	2
Milburnie Rd	Culpepper Ln	N Peartree Ln	3	Low	1	1	1	2	1

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Route	From	To	Suitability	Category	Comm. Of Concern	Feasibility	Full Time Suit.	TSP Suit.	Nonmotor. Propensity
N Mason St	Center St	Laura Duncan Rd	3	Low	1	1	1	2	2
N White St	Elm Ave	E JUNIPER AVE	3	Low	1	1	2	1	1
Westinghouse Blvd	N Raleigh Blvd	Capital Blvd	3	Low	1	1	1	2	2
N Salem St	Apex Pewy	Templeton St	3	Low	1	1	1	2	2
W Main St	Rand Mill Rd	St Marys St	3	Low	1	1	1	2	1
Trailwood Hills Dr	Lineberry Dr	Tryon Rd	3	Low	1	1	1	1	1
Thistledown Dr	Main Campus Dr / Trailwood Dr	Gorman St	3	Low	1	1	1	2	1
Sullivan Dr	Dan Allen Dr	Ligon St / Gorman St	3	Low	1	1	1	3	2
Sierra Dr	Lake Wheeler Rd	Lineberry Dr	3	Low	1	1	1	2	1
N West St	Tucker St	W Peace St	3	Low	1	1	1	2	3
North Hills Dr	Old Village Rd	Northbrook Dr	3	Low	1	1	2	3	2
North Hills Dr	Shellbrook Ct	Hearthridge Ct / Lynn Rd	3	Low	1	1	2	2	1
N Bloodworth St	E Lane St	Pace St	3	Low	1	1	1	1	3
James Jackson Ave	Towerview Ct	Rainbrook Dr / NW Cary Pkwy	3	Low	1	1	1	1	2
Hodges St	Atlantic Ave	Capital Blvd	3	Low	1	1	1	2	2
Lineberry Dr	Scattered Oak Ct	Mountain Mist Ct / Crestscene Trl	3	Low	1	1	1	2	1
Perry Creek Rd	Success Way	Fox Rd	3	Low	1	1	1	2	1
Wendell Blvd	Industrial Dr	N Oakwood Ave	3	Low	1	1	2	2	1
Wendell Blvd / Mack Todd Rd	Old Zebulon Rd	W Gannon Ave	3	Low	1	1	2	2	1
Louisburg Rd	Forestville Rd		3	Low	1	1	1	2	1
Raven Ridge Rd	Falls Of Neuse Rd	Raven Ridge Rd	3	Low	1	1	2	1	1
Louisburg Rd		Forestville Rd	3	Low	1	1	1	2	1
Trawick Rd	Lake Woodard Dr	New Bern Ave	2	Low	3	2	1	1	1
Trinity Rd	Sunday Dr	PETER KARMANOS JR DR / Youth Center Dr	2	Low	2	2	1	3	3
US 64 To W Williams St Ramp	US 64 Hwy W	W Williams St	2	Low	2	2	1	2	2
Louis Stephens Dr	Kit Creek Rd	Development Dr	2	Low	2	2	1	2	1
Louis Stephens Dr	Louis Stephens Dr	Kit Creek Rd	2	Low	2	2	1	2	1
Fox Rd	Fox Rd / Louisburg Rd	Perry Creek Rd	2	Low	2	2	1	2	1
Northbrook Dr	Six Forks Rd	North Hills Dr	2	Low	2	2	1	3	1
S NC 55 Hwy	Bitter Melon Dr	Lagenaria Dr	2	Low	1	2	1	3	1
S NC 55 Hwy	Clayton Rd	Hazelton Ln	2	Low	1	2	1	3	1
NC 55 Hwy	Indian Wells Rd / Morrisville Carpenter Rd	Good Hope Church Rd	2	Low	1	2	1	2	1
Sunset Lake Rd	Old Smithfield Rd		2	Low	1	2	1	3	1
Watkins Rd	Perimeter Park Dr	Chapel Hill Rd	2	Low	1	2	1	2	3
N Rogers Ln	Thunderidge Dr	Brookshadow Dr	2	Low	1	2	1	1	1
Weston Pkwy	Laurel Commons Way	Weston Estates Way / Sheldon Dr	2	Low	1	2	1	1	2
Paramount Pkwy	Carrington Mill Blvd	Perimeter Park Dr	2	Low	1	2	1	2	2
Green Oaks Pkwy	Premier Dr	Holly Springs New Hill Rd	2	Low	1	2	1	3	1
E Broad St	E Broad St	N Judd Pkwy NE	2	Low	1	2	1	3	1
Lead Mine Rd	Harvest Oaks Dr	Grosvenor Dr / Six Forks Rd	2	Low	1	2	1	1	2
North Hills Dr	Northbrook Dr	Shellbrook Ct	2	Low	1	2	1	1	1
James Jackson Ave	Carrousel Ln	Towerview Ct	2	Low	1	2	1	1	1
Sierra Dr	Rabbit Run / Henslowe Dr	Lake Wheeler Rd	2	Low	3	1	1	2	1
Landmark Dr	Lake Boone Trl / Nancy Ann Dr	Ed Dr	2	Low	3	1	1	2	3
Kaplan Dr	Melbourne Rd	Athens Dr	2	Low	3	1	2	1	2
Henslowe Dr	Carolina Pines Ave	Sierra Dr / Rabbit Run	2	Low	3	1	1	2	1
Fairway Dr	Club Plaza Rd / Suffolk Blvd	Bruce Cir	2	Low	3	1	1	2	1
Ed Dr	Landmark Dr	Stags Leap Cir	2	Low	3	1	1	2	3
Deboy St	Schaub Dr	I 440 Exit Ramp WB / Melbourne Rd	2	Low	3	1	2	1	1
Capability Dr	Varsity Dr	Research Dr	2	Low	3	1	1	3	2
N Allen Rd	Wait Ave	E JUNIPER AVE	2	Low	2	1	2	1	1
Ligon St	Sullivan Dr / Gorman St	Method Rd	2	Low	2	1	1	3	2
Glascock St	Culpepper Ln	Chatham Ln	2	Low	2	1	1	2	1
Cates Ave	Morrill Dr	Dan Allen Dr	2	Low	2	1	1	3	1
S Main St		Burlington Mills Rd	2	Low	1	1	1	2	1
E Garner Rd	New Rand Rd	Jones Sausage Rd	2	Low	1	1	1	2	1
E Broad St	N Ennis St	Cotten Farm Dr	2	Low	1	1	1	3	2
Jonesville Rd	Hampton Lake Dr / S Main St		2	Low	1	1	1	1	1
Battle Bridge Rd	Rock Quarry Rd	Granite Quarry Dr	2	Low	1	1	1	1	1
Barwell Rd	Rock Quarry Rd	Berkeley Lake Rd / Neals Creek Dr	2	Low	1	1	1	2	1

Segment Info			RED Lanes	Suitability	Detailed Differentiators		Implementation Guidance		
Route	From	To	Suitability	Category	Comm. Of Concern	Feasibility	Full Time Suit.	TSP Suit.	Nonmotor. Propensity
Milburnie Rd	Booker Dr	N King Charles Rd	2	Low	1	1	1	1	1
North Hills Dr	Northbrook Dr	Shellbrook Ct	2	Low	1	1	2	2	1
James Jackson Ave	Carrousel Ln	Towerview Ct	2	Low	1	1	1	1	2
Fox Rd	Louisburg Rd	Perry Creek Rd	2	Low	1	1	2	2	1
Cates Ave	Morrill Dr	Dan Allen Dr	2	Low	1	1	1	3	2
Northbrook Dr	Six Forks Rd	North Hills Dr	2	Low	1	1	1	3	2

APPENDIX B – SCOPING SHEET MENU

The CAMPO RED Lanes study generated a RED Lanes Toolkit that evaluates the suitability of a given corridor or segment for RED Transit Priority Lanes and reports Implementation Guidance measures that highlight potential design, operations, and enforcement elements for candidate corridors. The toolkit outputs help identify opportunities for strategic investment in RED Lanes as low-cost stand-alone projects or additions to ongoing projects. RED Lanes are part of a broad regional strategy to enhance transit mobility and visibility throughout the CAMPO region to maintain a safe, convenient, and efficient multimodal system.

This guide supports the development of RED Lane Candidate Corridor Scoping Sheets. The sheets present suitability criteria and appropriate potential design, operational, and enforcement elements for candidate RED Lane corridors based on suitability scores, Detailed Differentiation measures, and Implementation Guidance measures. The Candidate Corridor Scoping Sheet is intended to help potential project sponsors understand corridor suitability and the range of treatments that warrant further study for the prospective incorporation of RED Lanes into transportation plans at a corridor and/or systems level.

This Scoping Guide is intended to aid in generating Candidate Corridor Scoping Sheets based on RED Lanes Toolkit outputs. It includes:

- Background on the scoring process and interpretation guidance
- A menu of cost considerations for key RED Lanes elements
- Example typical sections for with RED Lanes visualized.

RED LANES TOOLKIT OUTPUTS AND INTERPRETATION

SUITABILITY SCORES

A data-driven, hierarchical approach was taken to derive a RED Lanes suitability score for each corridor. Different measures regarding the corridor, such as traffic, travel demand, transit operations, etc. were taken into consideration. Once each measure was individually assessed, they were combined to understand the complete picture of RED Lanes suitability. Weights for each dimension in the combined suitability score were determined in coordination with the RED Lanes CTT and the CAMPO Technical Coordinating Committee. Table A shows a brief overview of each measure, its characteristics and weightage in overall score.

The calculation of RED Lanes suitability in the study area results in an overall score for each corridor as an integer between 2 and 9.[5] A score of 9 denotes very high suitability for RED Lanes while a score of 2 denotes that RED Lanes are not suitable in that segment. A brief interpretation of each score is described in Table B. This overall score does not provide a full picture of its constituent score components (that is, scores in each category) but provides a single assessment of the suitability for RED Lane implementation in a corridor.

[5] The suitability process could nominally generate corridor scores between 1 and 10, but there were no observed instances of corridors with scores at either extreme (1 or 10).

Table A: Suitability Score Derivation Overview Matrix

Category	Weight in Score	Measure	Source	Weight in Category	Value Range	Value Increment	Tier Range
Travel Demand	30%	Transit Ridership	Triangle Regional Model (2045)	60%	0 to 35000+	1,500 to 5,000	1 to 10
		Traffic Volume		40%	0 to 70,000+	5,000 to 20,000	1 to 10
Transit Operations	25%	On-Time Performance	Route level OTP statistics from transit agencies.	25%	0 to 100%	5% after 75%	10 to 0
		Service Frequency	Headways from Wake Bus Plan and MTP for 2018, 2024, 2027 and 2045	50%	0 to 12+	2 to 4	0 to 10
		Transit Travel Speed	TRM highway network bus speed estimates	25%	0 to 20+	4 to 8	10 to 0
Highway Operations	30%	Vehicle Delay	Ratio of congested to free flow speed from TRM (2045)	50%	0 to 1	0.05 to 0.1	10 to 1
		V/C ratio	TRM (2045)	50%	0 to 1.2+	0.10 to 0.15*	2 to 10
Context and Design	15%	Activity Density	Jobs and Dwellings per acre from TRM Traffic Analysis Zone Data	50%	0 to 49+	5 to 28	0 to 10
		Intersection Density	Intersections per square mile from EPA Smart Location Database	50%	0 to 266+	30 to 126	0 to 10

**Values from 0 to 0.75 are given low suitability score of 2. Values from 0.75 to 1.05 are given an incremental suitability score. Values higher than 1.05 are given a decreasing suitability score*

Table B: Suitability Score Interpretation

Score	RED Lanes Suitability	Interpretation
9	High	Most parameters observed on the segment score high or very high. These segments are the most suitable for RED Lanes implementation.
8		
7	Medium/High	Medium to high scores on many parameters observed on this segment. Low scoring parameters may be those with less emphasis in the weighted scoring process. These segments are likely suitable for RED Lanes implementation but merit additional study.
6		
5	Low/Medium	Low to medium scores on most parameters observed on this segment. These segments are not suitable for RED Lanes implementation at this time but may be considered for scenario analysis applications of the RED Lanes toolkit.
4		
3	Low	None of the parameters observed on the segment score high enough to qualify for RED Lanes implementation. These segments are not suitable for RED Lanes implementation.
2		

In addition to the suitability scores, the RED Lanes toolkit generates Detailed Differentiator and Implementation Guidance metrics.

Detailed Differentiators

Detailed Differentiator scores embellish the suitability score with considerations for whether a corridor serves **Communities of Concern** (promoting equity in transportation) or is likely to be **feasible**. For example, if two candidate corridors have similar RED Lanes suitability scores, but one has a higher feasibility score and serves communities of concern, it is reasonable to prioritize this corridor based on the differentiation metrics.

Regional funding priorities may consider Detailed Differentiator scores in addition to suitability scores.

Implementation Guidance

Implementation Guidance metrics focus on the design, operational, and/or enforcement elements to consider for a potential RED Lanes project. Table C provides basic interpretations of the Implementation Guidance variables; detailed descriptions are offered below.

- The **Full Time Suitability** score, highlights corridors where RED Lanes warrant consideration for full-time versus part-time application. Full-time application often involves the use of RED paint and restricts travel in the lane to transit vehicles, emergency vehicles, cars and trucks making right turns or entering/leaving driveway, and bicyclists in appropriate contexts throughout the day. Part time applications generally should not use red paint and restrict travel only during select hours (peak commuting hours, generally). Appropriate enforcement strategies to consider are also based on the Full Time Suitability score. In corridors with Low Full Time Suitability, police enforcement is recommended. In Medium and High Full Time Suitability corridors, camera enforcement is recommended. Bus mounted cameras have lower cost impact and are recommended in situations where the cameras are not planned to be used to enforce other traffic violations.

- **Transit Signal Priority (TSP) Suitability** flags corridors where TSP merits consideration as an operational enhancement accompanying a RED Lane project. There are different TSP technologies to consider and costs vary based on the number of intersections and transit vehicles. Corridors with High TSP Suitability should consider the inclusion of TSP systems as part of RED Lane project scoping. Corridors with Low TSP Suitability should not consider the inclusion of TSP systems, and those with Medium TSP Suitability should consider it if operational treatments (Intelligent Transportation Systems, e.g.) are already in place or planned in the corridor.
- **Nonmotorized Propensity** highlights corridors where non-motorized facilities should be considered as RED Lane project components. In some cases, bicyclists may be allowed to use the RED Lane, sharing it with other approved vehicles (buses, emergency vehicles, and turning cars). In other contexts, fully separated bicycle and pedestrian facilities may be warranted. Nonmotorized facilities should be included in RED Lane project scoping where the non-motorized score is High or Medium or where safety data indicate a need for enhanced bicycle/pedestrian facilities.

Table C: RED Lanes Elements to Consider Based on Implementation Guidance

Code	Cost Element	Candidate Corridor Attributes
LANE TYPE		
L1	Standard Bus Lane – White Pavement Striping	**Full-time suitability** is Low or Medium
L2	Red Paint Bus Lane	**Full-time suitability** is Medium or High
ENFORCEMENT		
E1	Police enforcement	**Full time suitability** is Low
E2	Bus mounted Camera	**Full time suitability** is Medium or High
E3	Stationary Camera	**Full time suitability** is High
TRANSIT SIGNAL PRIORITY		
T1	Center to Center systems	**TSP suitability** is Medium or High
T2	GPS based System	

Cost Considerations

This section provides a high-level assessment of the costs associated with various RED Lane capital and enforcement strategies. The capital and enforcement costs are calculated in Table D based on the following assumptions.

- **Hours of operation** - Five days a week during peak periods (6 hours per day) for fifty weeks.
- **Bus Frequency** - Eight buses per hour (four per hour per direction).
- **Lanes considered** – 2 outside lanes, 11 feet wide

Table D: Cost Consideration Matrix

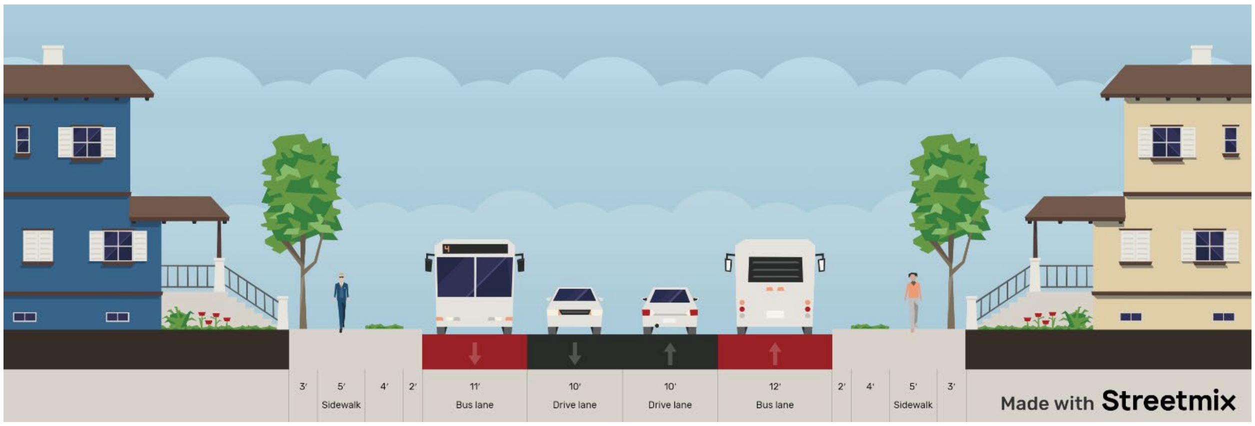
Code	Cost Element	Capital Cost		Maintenance cost	
Lane Type					
L1	Standard Bus Lane – White Pavement Striping	$200,000	per mile	$10,000	per mile per year
L2	Red Paint Bus Lane	$580,000	per mile	$10,000	per mile per year (to be repainted every 5 years)
Enforcement					
E1	Police enforcement			$75,000	1500 hours of enforcement per year per mile
E2	Bus mounted Camera	$95,000	for 10 buses running on a route at 15-minute headway	$7,500	for 10 buses per year
E3	Stationary Camera	$130,000	4 cameras per mile	$40,000	per mile per year
Transit Signal Priority					
T1	Center to Center systems	$200,000 to $600,000	Depending on the total number of TSP intersections		
T2	GPS based System	$ 5,000	per bus		
		$ 10,000	per intersection		

Detailed design and traffic studies are required to assess the impacts of RED Lanes on traffic flow, street design, and other related elements. These estimates only include improvements between the curbs and do not include right-of-way acquisition, shifting utilities or any changes to the streetscape outside the curbs. If a corridor is planned to be widened between 2020 and 2045, it is indicated in the description of that corridor. While calculating the costs of the corridor, a 50% contingency is recommended to be added to this cost which will include Design costs, Oversight and other contingencies.

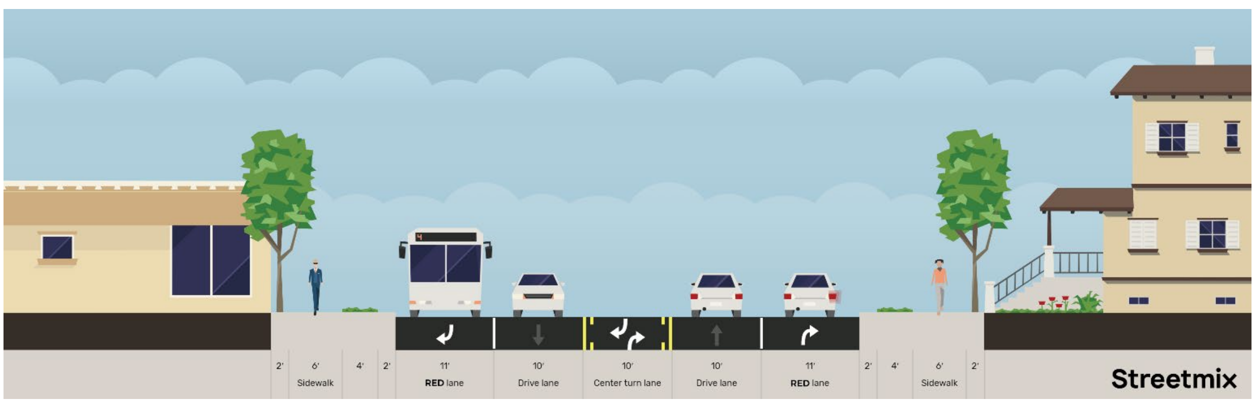
Street Section Typologies

This section presents example roadway cross-sections with RED Lanes included. **The RED Lanes study makes no recommendation of a particular section typology for any corridor**. Rather, it highlights suitable corridors for further study to evaluate traffic impacts, assess feasibility, and determine appropriate facility design.

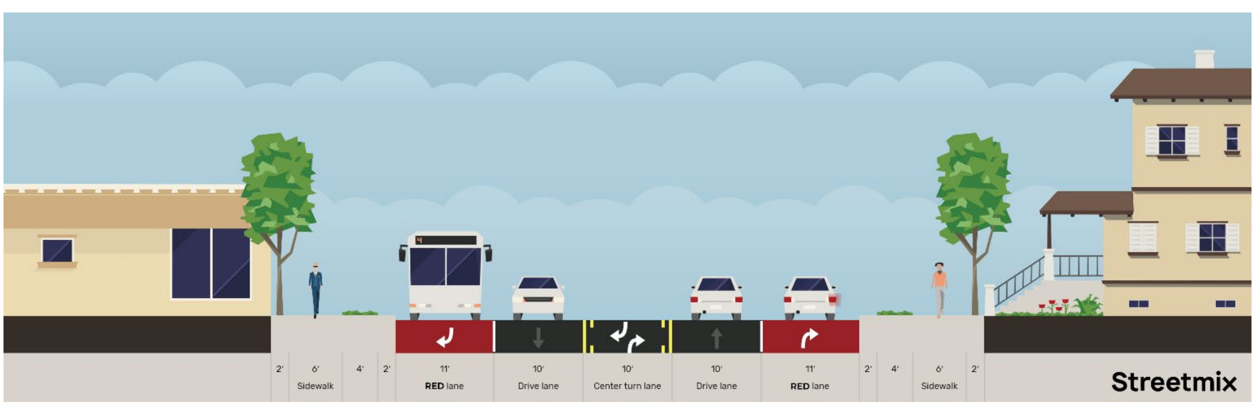
Type A: 4 Lane road with 2 general purpose lanes and 2 RED Lanes



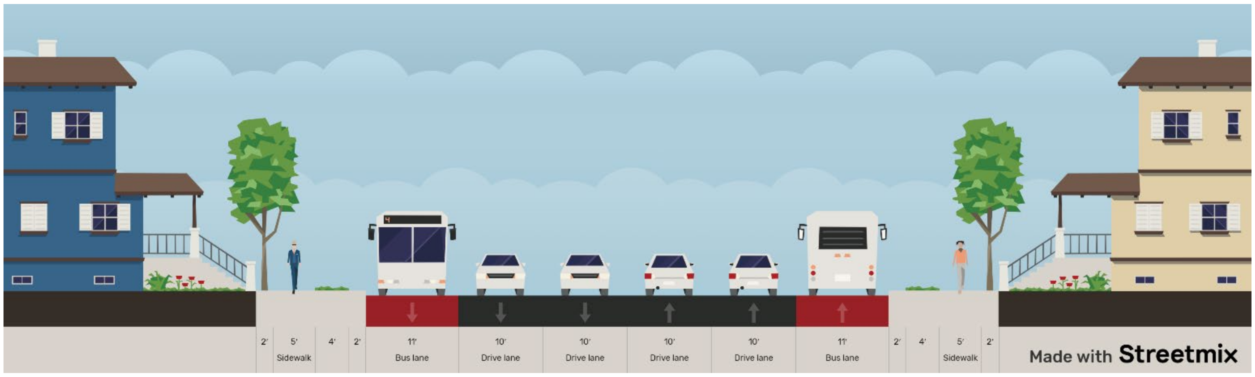
Type B1 – 5 Lane road with 2 general purpose lanes 1 center turn lane, and 2 RED Lanes



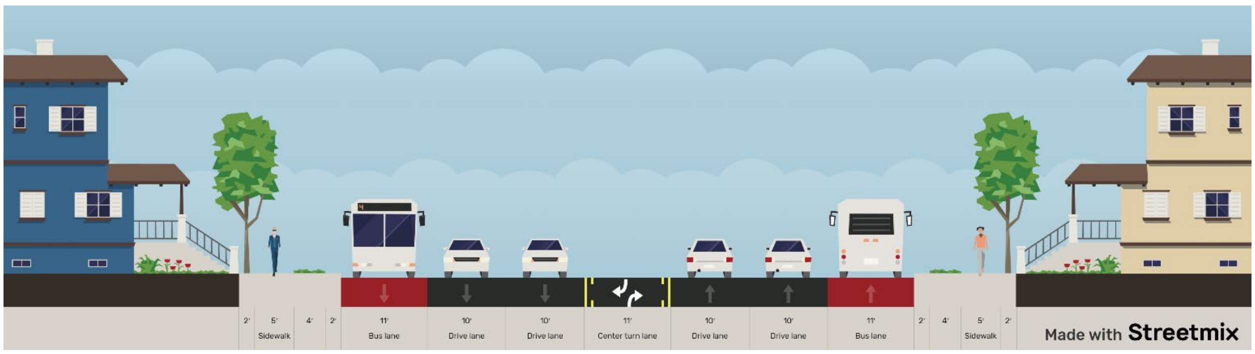
Type B2 – 5 Lane road with 2 general purpose lanes, 1 center turn lane, and 2 RED Lanes



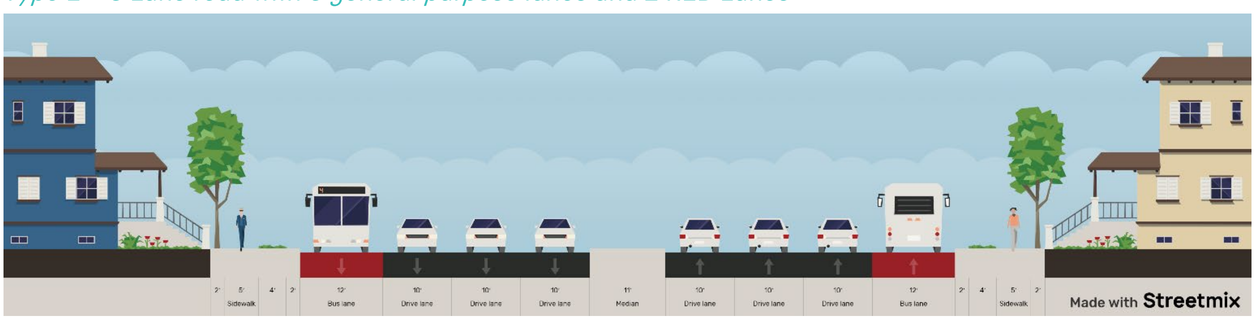
Type C – 6 Lane road with 4 general purpose lanes and 2 RED Lanes



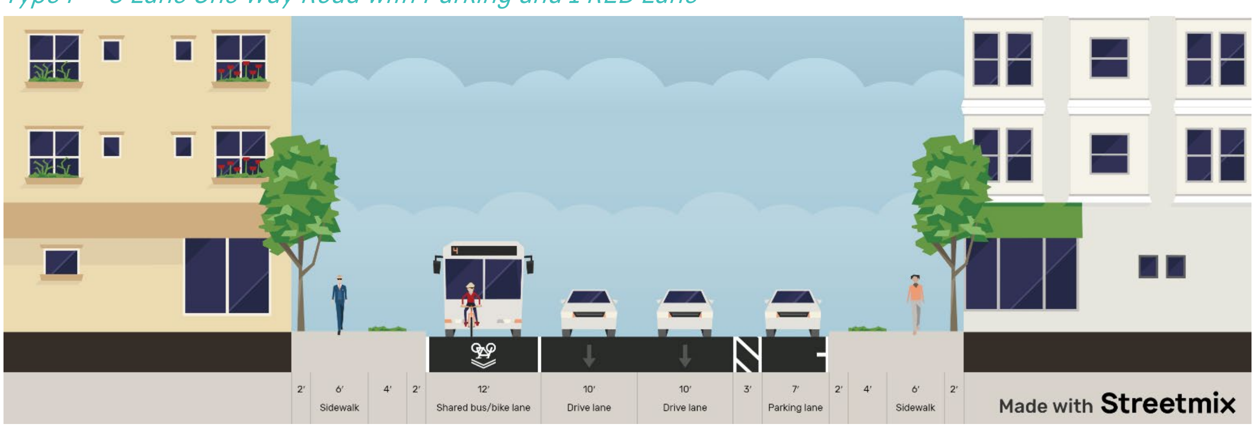
Type D – 7 Lane road with 4 general purpose lanes, 1 center turn lane and 2 RED Lanes



Type E – 8 Lane road with 6 general purpose lanes and 2 RED Lanes



Type F – 3 Lane One Way Road with Parking and 1 RED Lane



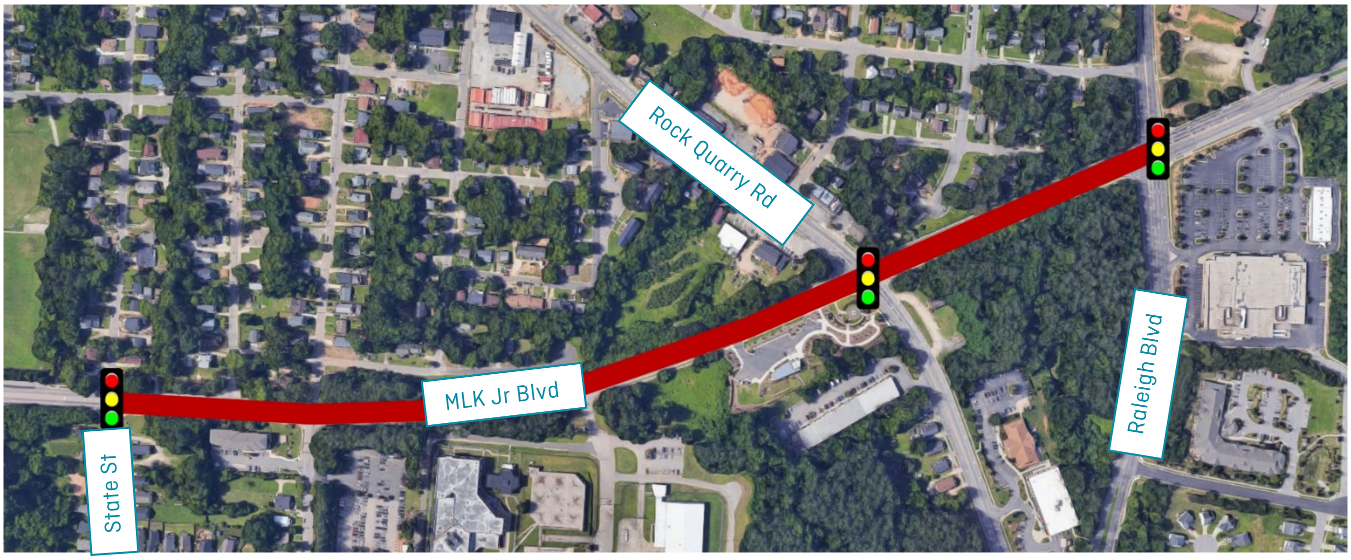
APPENDIX C - CANDIDATE CORRIDOR SCOPING SHEETS

1. **Martin Luther King Jr. Blvd.** – State St. to Raleigh Blvd.
2. **Wake Forest Rd.** – St. Albans Dr to Colby Dr.
3. **Kildaire Farm Rd.** – Maynard Rd. to Glasgow Rd.
4. **Millbrook Rd.** – Departure Dr. to Capital Blvd.
5. **Main Street** – Capcom Ave. to Selsey Dr.
6. **Six Forks Rd.** – Wake Forest Rd. to Anderson Dr.
7. **Glenwood Ave.** – Creedmoor Rd. to Lead Mine Rd.
8. **Fayetteville Rd.** – Manor Ridge Rd. to Caddy Rd.
9. **Hillsborough St.** – Glenwood Ave to Dan Allen Dr.
10. **NC 55** – Morrisville Pkwy. to Carpenter Fire Station Rd.

CORRIDOR: MARTIN LUTHER KING JR BLVD

From State Street to Raleigh Blvd. Length: 3200 Feet Signalized Intersections: 3
Average Annual Daily Traffic: 20,500 to 23,500

This Corridor Scoping Sheet presents suitability criteria and appropriate potential design, operational, and enforcement elements for a candidate RED Lane corridor. The information on this sheet is intended to help potential project sponsors understand the corridor suitability and range of treatments that might warrant further study.



CORRIDOR SCORES AND INTERPRETATION

As shown below, in the regionwide analysis for RED Lanes suitability, this corridor received a score of 7 out of 10, indicating moderate-to-strong performance or need across all suitability dimensions (travel demand, highway operations, transit operations, and context/design).

Suitability Score	7
Travel Demand Score	6
Highway Operations Score	9
Transit Operations Score	6
Context and Design Score	5

Detailed Differentiators	
Communities of Concern Served	High
Feasibility	Medium
Implementation Guidance	
Nonmotorized propensity	High
Transit Signal Priority suitability	Medium
Full Time suitability	High

Suitability Score of 7 = Medium/High RED Lanes Suitability - Medium to high scores on many parameters observed on this segment. Low scoring parameters may be those with less emphasis in the weighted scoring process. A high score for *Communities of Concern Served* and a medium *Feasibility* rating make this segment suitable for a detailed implementation study.

High Transit Signal Priority Suitability warrants application of TSP systems at signalized intersections. *High Full Time Suitability* warrants application of RED painted bus lane and either a bus mounted or stationary camera for enforcement. *High Nonmotorized Propensity* indicates that bicycle and pedestrian facilities should be a key component in any detailed implementation study.

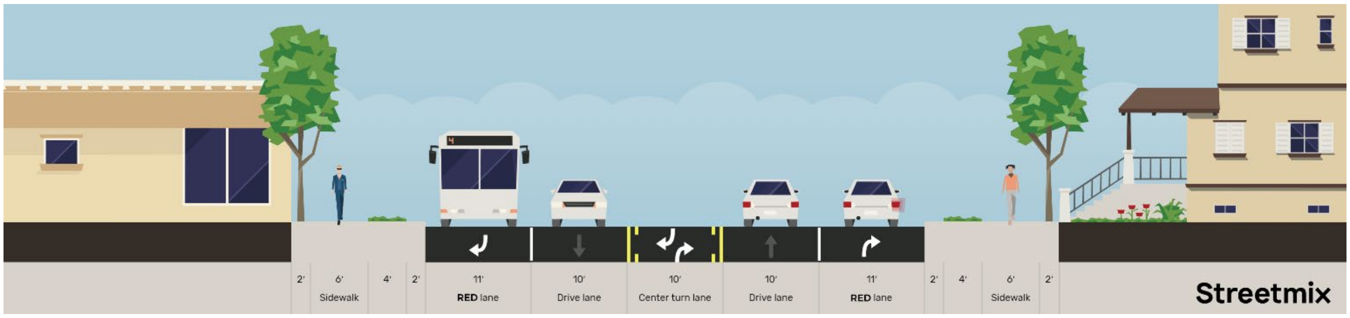
POTENTIAL STREET CONFIGURATIONS

Lower-investment configuration

Potential Section: Type B1 - 5 Lane road with 2 general purpose lanes, 1 center turn lane, and 2 RED Lanes

Lane Type: L1 – Standard Bus Lane – White Pavement Striping | **Enforcement Type**: E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system

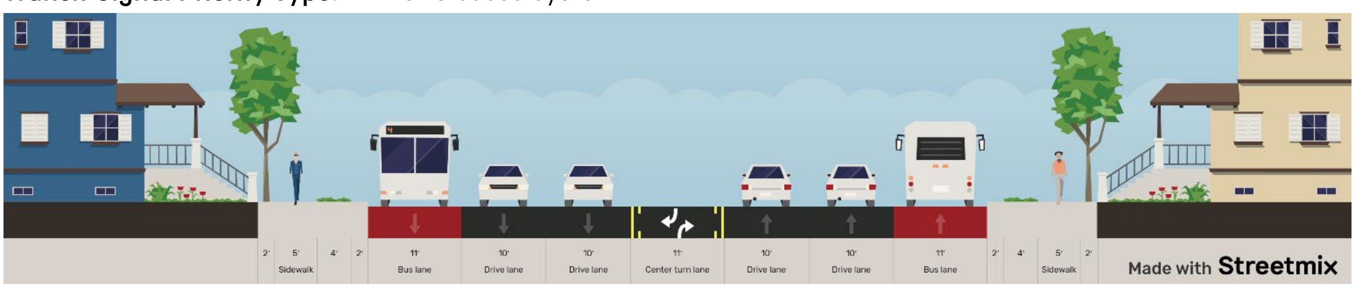


Higher-investment configuration

Potential Section: Type D - 7 Lane road with 4 general purpose lanes, 1 center turn lane, and 2 RED Lanes (if RED Lanes were implemented as part of a widening project)

Lane type: L2 – RED Paint Bus Lane | **Enforcement Type**: – E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system



All changes may require additional design and traffic impact studies. Some changes may require National Environmental Protection Act (NEPA) and/or other studies. In future, an exploration into widening this segment to 6 lanes (with 4 drive lanes, 2 RED Lanes and a median) may be warranted based on traffic volumes in this corridor. That may require additional ROW and shifting of utilities.

Sketch-level cost estimates (excluding ROW) for elements that might be considered in further study

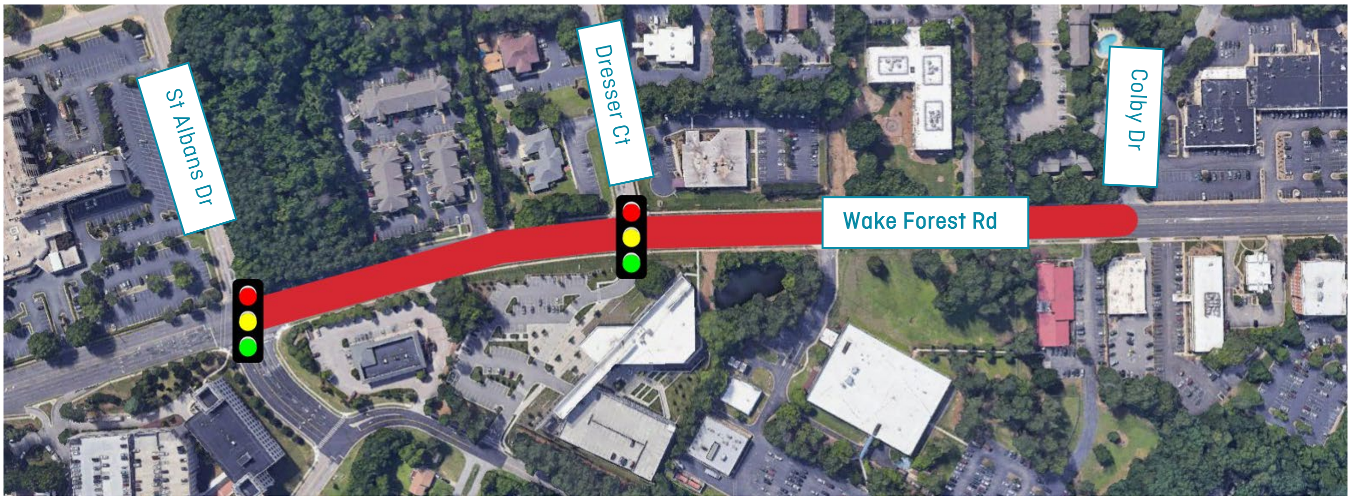
Element	Lower Investment Cost	Higher Investment Cost
Roadway widening	n/a	$3,700,000
Paint Cost (to be applied every 5 years)	$130,000	$320,000
Transit Signal Priority (10 buses)	$80,000	$80,000
Bus-mounted camera (10 buses)	$95,000	$95,000
Subtotal	*$305,000*	*$495,000*
Design + Oversight + Contingency (~50%)	$150,000	$250,000
Total Capital Costs	**$455,000**	**$4,445,000**
Maintenance and Enforcement (every 5 years)	**$70,000**	**$70,000**

This list of elements is not exhaustive. These elements could be employed to enhance the functioning of the corridor in terms of Right Turns, Emergency Vehicles and Driveway Access. Cost estimates only include RED Lanes elements.

Corridor: Wake Forest Road

From St Albans Dr to Colby Dr   Length: 1900 feet   Signalized Intersections: 2
AADT 2018: 44,000

This Corridor Scoping Sheet presents suitability criteria and appropriate potential design, operational, and enforcement elements for a candidate RED Lane corridor. The information on this sheet is intended to help potential project sponsors understand the corridor suitability and range of treatments that might warrant further study.



Corridor Scores and Interpretation

In the regionwide analysis for RED Lanes suitability, this corridor received a score of 7. This suggests that based on the analysis, this segment may exhibit characteristics which constrict transit movement, right turns and driveway access.

Suitability Score	7
Travel Demand Score	8
Highway Operations Score	9
Transit Operations Score	6
Context and Design Score	4

Detailed Differentiators	
Communities of Concern Served	Med
Feasibility	Med
Implementation Guidance	
Nonmotorized propensity	High
TSP suitability	Med
Full-time suitability	High

Suitability Score of 7 = Medium/High RED Lanes Suitability -Medium to high scores on many parameters observed on this segment. Low scoring parameters may be those with less emphasis in the weighted scoring process. A medium score for *Communities of Concern Served* and *Feasibility* make this segment suitable for a detailed implementation study.

High non-motorized propensity indicates potential inclusion of bicycle and pedestrian elements in the design. *Medium Transit Signal Priority Suitability* warrants further study into application of TSP system at signalized intersections. *High full-time suitability* warrants application of RED painted bus lane and either a bus mounted or stationary camera for enforcement.

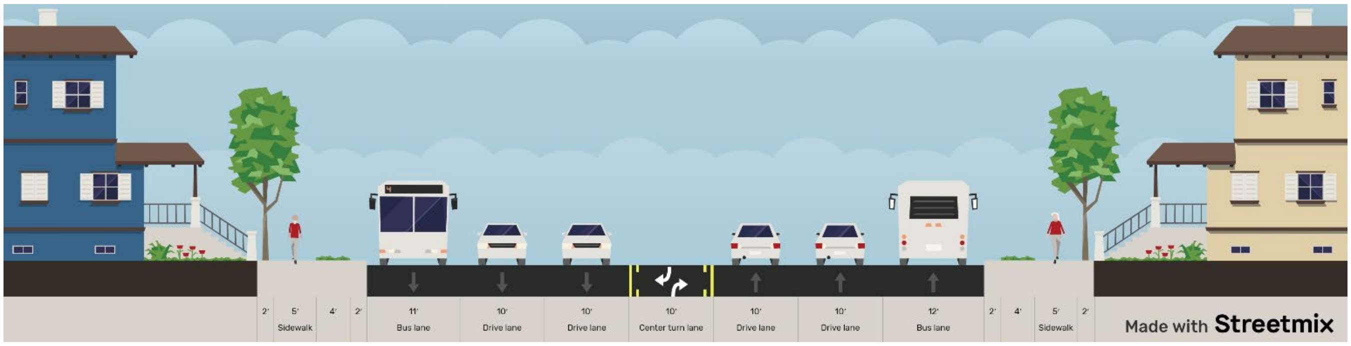
Potential Street Configurations

Lower-investment configuration

Potential Section: Type C1 - 7 Lane road with 4 general purpose lanes, 1 center turn lane, and 2 RED Lanes

Lane Type: L1 – Standard Bus Lane – White Pavement Striping | **Enforcement Type:** E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system

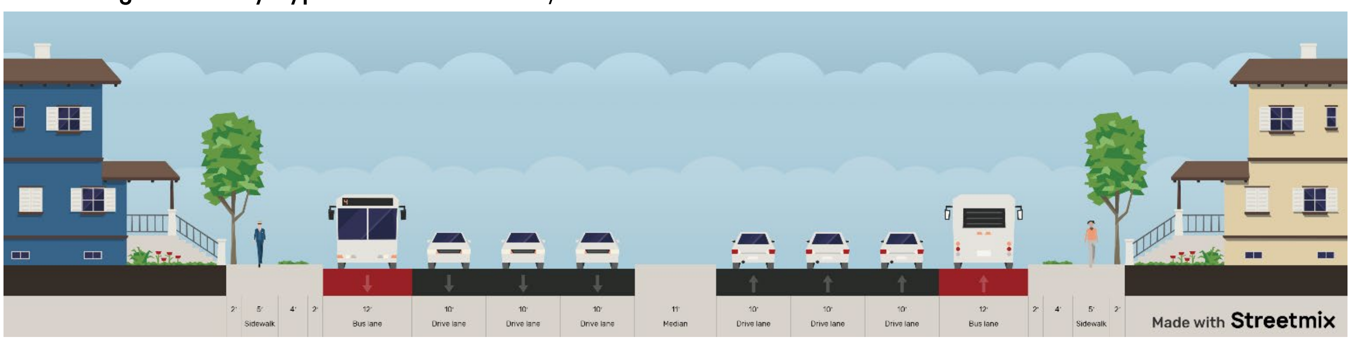


Higher-investment configuration

Potential Section: Type D - 8 Lane road with 4 general purpose lanes, median, and 2 RED Lanes

Lane type: L2 – RED Paint Bus Lane | **Enforcement Type**: – E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system



Changes may require additional design and traffic impact studies. Some changes may require National Environmental Protection Act (NEPA) and/or other studies. Cost considerations for potential road-widening is beyond the scope of this study.

Sketch-level cost estimates (excluding ROW) for elements that might be considered in further study

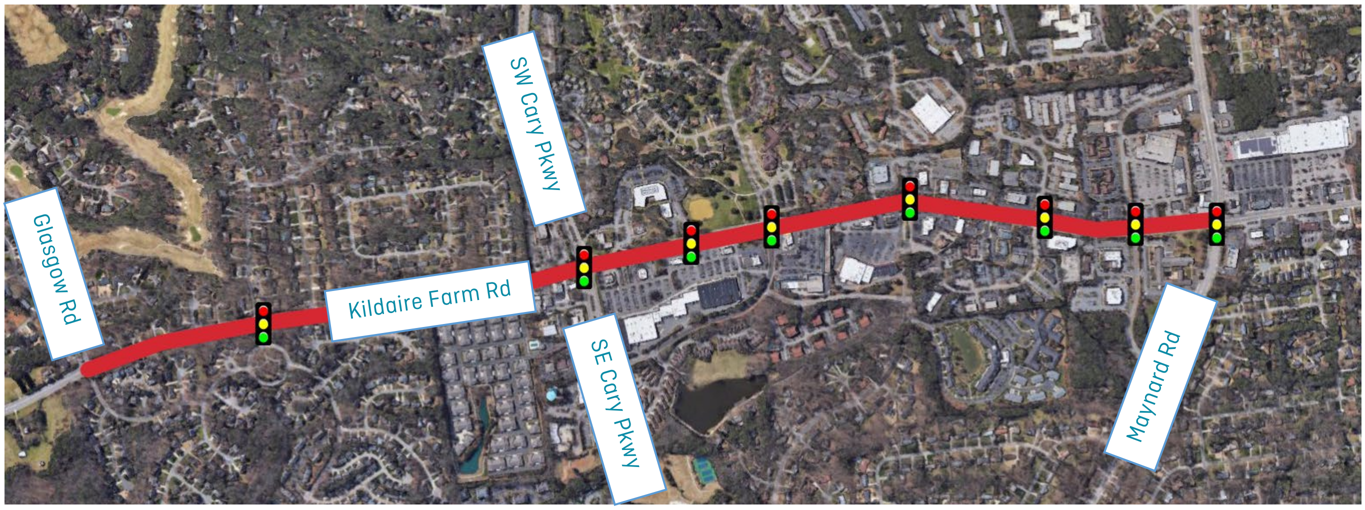
Element	Lower Investment Cost	Higher Investment Cost
Road Widening		$2,700,000
Paint Cost (to be applied every 5 years)	$72,000	$209,000
Transit Signal Priority (10 buses)	$70,000	$70,000
Bus-mounted camera (10 buses)	$95,000	$95,000
Subtotal	$237,000	$374,000
Design + Oversight + Contingency (~50%)	$118,500	$187,000
Total Capital Costs	**$355,500**	**$3,261,000**
Maintenance and Enforcement (every 5 years)	**$56,000**	**$56,000**

This list of elements is not exhaustive. These elements could be employed to enhance the functioning of the corridor in terms of Right Turns, Emergency Vehicles and Driveway Access. Cost estimates only include RED Lanes elements.

CORRIDOR: KILDAIRE FARM ROAD

From Maynard Rd to Glasgow Rd   Length: 8870 feet
Signalized Intersections: 8   AADT 2018: 29,000

This Corridor Scoping Sheet presents suitability criteria and appropriate potential design, operational, and enforcement elements for a candidate RED Lane corridor. The information on this sheet is intended to help potential project sponsors understand the corridor suitability and range of treatments that might warrant further study.



CORRIDOR SCORES AND INTERPRETATION

In the regionwide analysis for RED Lanes suitability, this corridor received a score of 7. This suggests that based on the analysis, this segment may exhibit characteristics which constrict transit movement, right turns and driveway access.

Suitability Score	7
Travel Demand Score	7
Highway Operations Score	9
Transit Operations Score	6
Context and Design Score	4

Detailed Differentiators	
Communities of Concern Served	Med
Feasibility	Med
Implementation Guidance	
Nonmotorized propensity	Med
TSP suitability	Med
Full-time suitability	High

Suitability Score of 7 = Medium/High RED Lanes Suitability Medium to high scores on many parameters observed on this segment. Low scoring parameters may be those with less emphasis in the weighted scoring process. A medium score for *Communities of Concern Served* and *Feasibility* make this segment suitable for a detailed implementation study.

Medium non-motorized propensity indicates a possibility of including bicycle and pedestrian elements in the design. *Medium Transit Signal Priority Suitability* warrants further study into application of TSP system at signalized intersections. *High full-time suitability* warrants application of RED painted bus lane and either a bus mounted or stationary camera for enforcement.

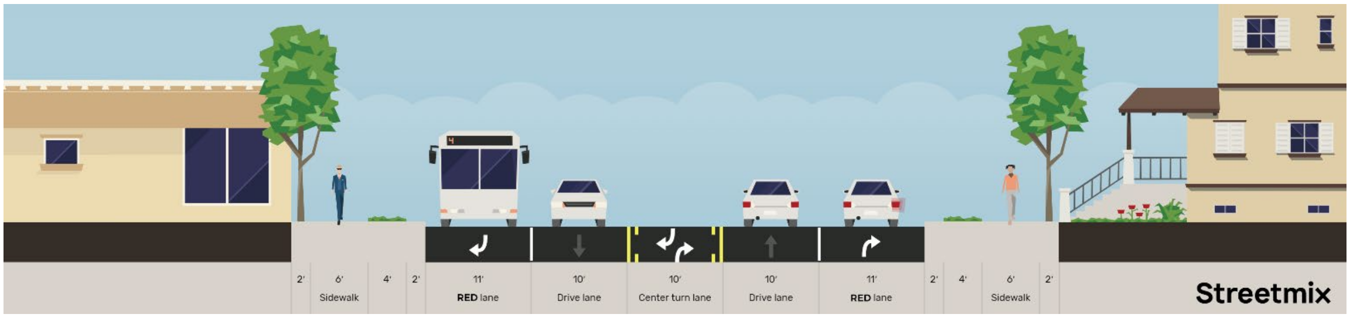
POTENTIAL STREET CONFIGURATIONS

Lower-investment configuration

Potential Section: Type B1 - 5 Lane road with 2 general purpose lanes, 1 center turn lane, and 2 RED Lanes

Lane Type: L1 – Standard Bus Lane – White Pavement Striping | **Enforcement Type**: E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system

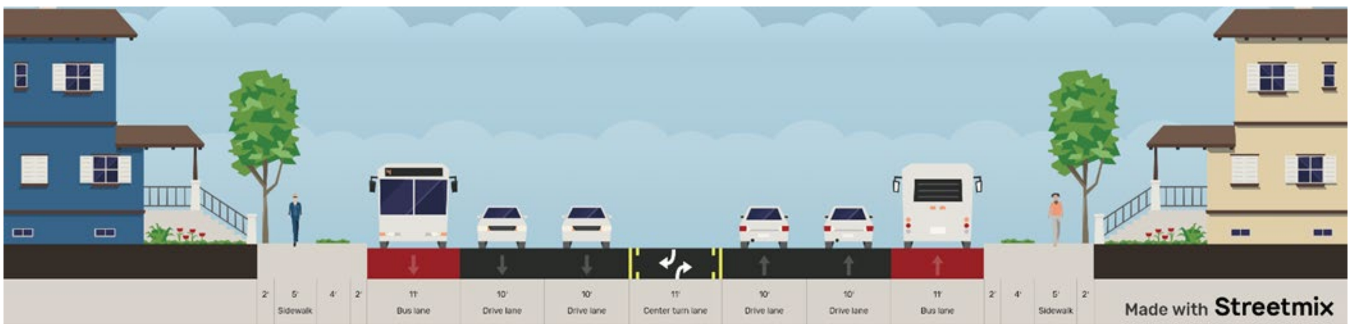


Higher-investment configuration

Potential Section: Type D - 7 Lane road with 4 general purpose lanes, 1 center turn lane, and 2 RED Lanes

Lane type: L2 – RED Paint Bus Lane | **Enforcement Type**: – E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system



All changes may require additional design and traffic impact studies. Some changes may require NEPA and other studies. In future, an exploration into widening this segment to 6 lanes (with 4 drive lanes, 2 RED Lanes and a median) may be warranted based on traffic volumes in this corridor. That may require additional ROW and shifting of utilities. Cost considerations for such a possibility is beyond the scope of this study.

Sketch-level cost estimates (excluding ROW) for elements that might be considered in further study

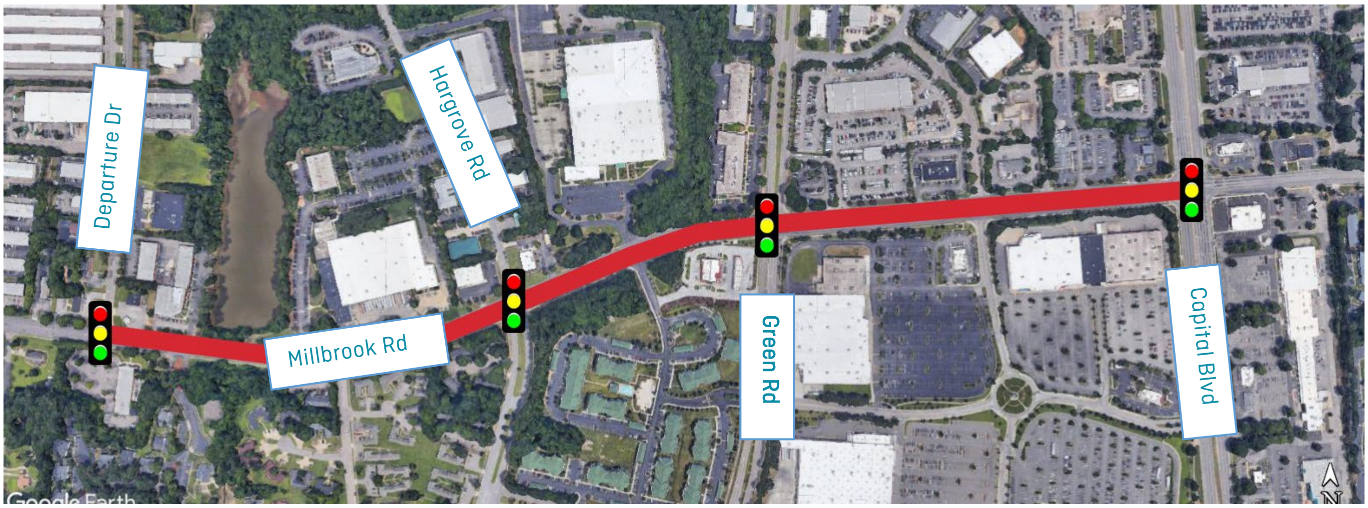
Element	Lower Investment Cost	Higher Investment Cost
Road Widening		$10,200,000
Paint Cost (to be applied every 5 years)	$336,000	$975,000
TSP (10 buses)	$130,000	$130,000
Bus-mounted camera (10 buses)	$95,000	$95,000
Subtotal	$561,000	$1,200,000
Design + Oversight + Contingency (~50%)	$280,500	$600,000
Total Capital Costs	**$841,500**	**$12,000,000**
Maintenance and Enforcement (every 5 years)	**$122,000**	**$122,000**

This list of elements is not exhaustive. These elements could be employed to enhance the functioning of the corridor in terms of Right Turns, Emergency Vehicles and Driveway Access. Cost estimates only include RED Lanes elements.

CORRIDOR: MILLBROOK ROAD

From Departure Dr to Capital Blvd Length: 4700 feet Signalized Intersections: 4
AADT 2018: 25,000

This Corridor Scoping Sheet presents suitability criteria and appropriate potential design, operational, and enforcement elements for a candidate RED Lane corridor. The information on this sheet is intended to help potential project sponsors understand the corridor suitability and range of treatments that might warrant further study.



CORRIDOR SCORES AND INTERPRETATION

In the regionwide analysis for RED Lanes suitability, this corridor received a score of 7. This suggests that based on the analysis, this segment may exhibit characteristics which constrict transit movement, right turns and driveway access.

Suitability Score	7
Travel Demand Score	6
Highway Operations Score	9
Transit Operations Score	6
Context and Design Score	4

Detailed Differentiators	
Communities of Concern Served	Med
Feasibility	Med
Implementation Guidance	
Nonmotorized propensity	Med
TSP suitability	Med
Full-time suitability	High

Suitability Score of 7 = Medium/High RED Lanes Suitability Medium to high scores on many parameters observed on this segment. Low scoring parameters may be those with less emphasis in the weighted scoring process. A medium score for *Communities of Concern Served* and *Feasibility* make this segment suitable for a detailed implementation study.

Medium non-motorized propensity indicates a possibility of including bicycle and pedestrian elements in the design. *Medium Transit Signal Priority Suitability* warrants further study into application of TSP system at signalized intersections. *High full-time suitability* warrants application of RED painted bus lane and either a bus mounted or stationary camera for enforcement.

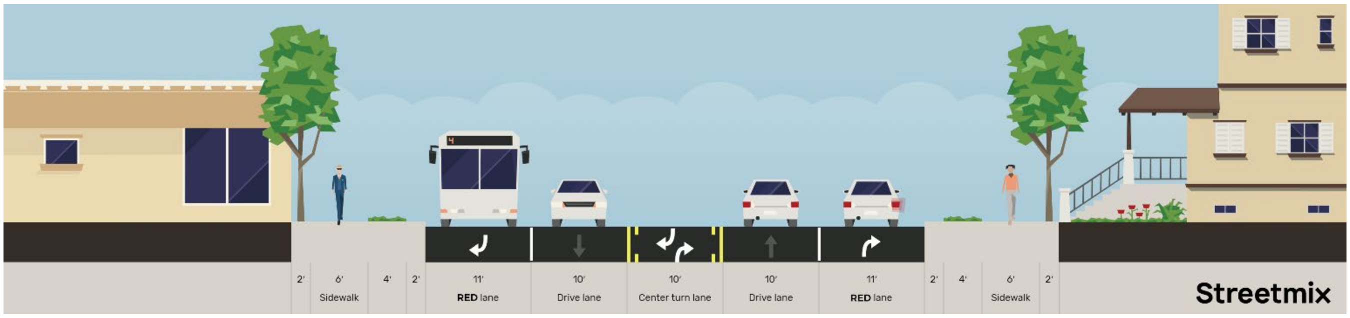
Potential Street Configurations

Lower-investment configuration

Potential Section: Type B1 - 5 Lane road with 2 general purpose lanes, 1 center turn lane, and 2 RED Lanes

Lane Type: L1 – Standard Bus Lane – White Pavement Striping | **Enforcement Type**: E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system

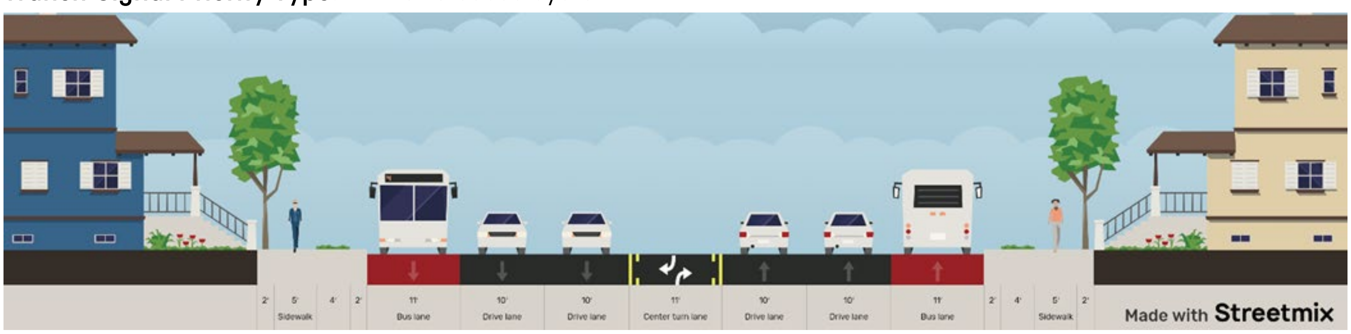


Higher-investment configuration

Potential Section: Type D - 7 Lane road with 4 general purpose lanes, 1 center turn lane, and 2 RED Lanes

Lane type: L2 – RED Paint Bus Lane | **Enforcement Type**: – E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system



All changes may require additional design and traffic impact studies. Some changes may require NEPA and other studies. In future, an exploration into widening this segment to 6 lanes (with 4 drive lanes, 2 RED Lanes and a median) may be warranted based on traffic volumes in this corridor. That may require additional ROW and shifting of utilities. Cost considerations for such a possibility is beyond the scope of this study.

Sketch-level cost estimates (excluding ROW) for elements that might be considered in further study

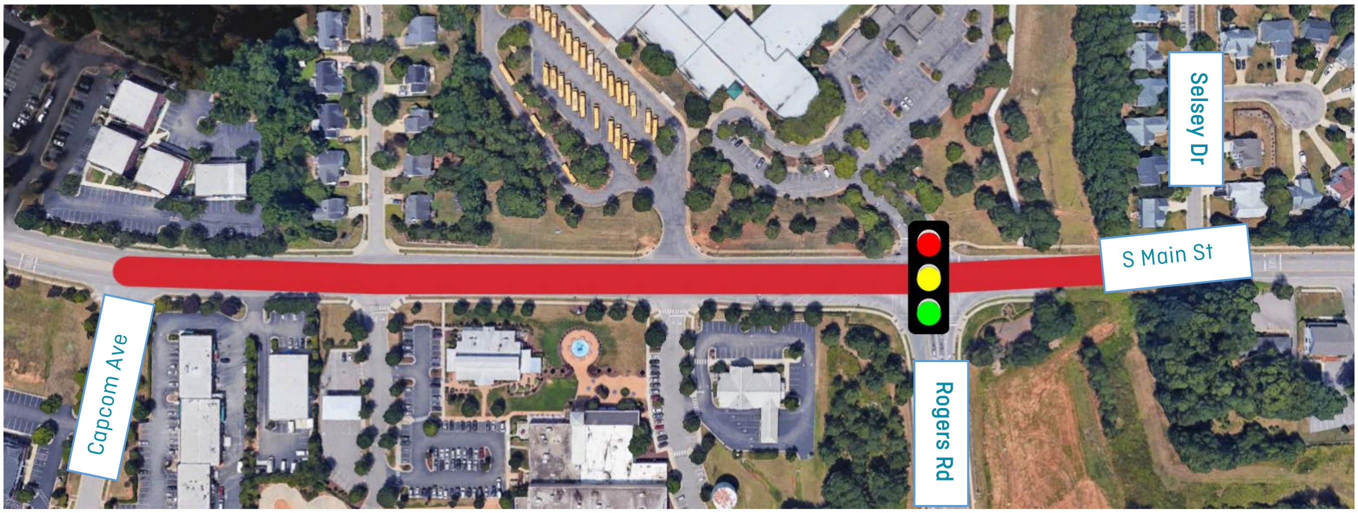
Element	Lower Investment Cost	Higher Investment Cost
Road Widening		$5,400,000
Paint Cost (to be applied every 5 years)	$179,000	$517,000
TSP (10 buses)	$90,000	$90,000
Bus-mounted camera (10 buses)	$95,000	$95,000
Subtotal	$364,000	$702,000
Design + Oversight + Contingency (~50%)	$182,000	$351,000
Total Capital Costs	**$546,000**	**$6,453,000**
Maintenance and Enforcement (every 5 years)	**$83,000**	**$83,000**

This list of elements is not exhaustive. These elements could be employed to enhance the functioning of the corridor in terms of Right Turns, Emergency Vehicles and Driveway Access. Cost estimates only include RED Lanes elements.

CORRIDOR: S MAIN STREET (WAKE FOREST)

From Capcom Ave to Selsey Dr   Length: 1700 feet   Signalized Intersections: 1
AADT 2018: 28,500

This Corridor Scoping Sheet presents suitability criteria and appropriate potential design, operational, and enforcement elements for a candidate RED Lane corridor. The information on this sheet is intended to help potential project sponsors understand the corridor suitability and range of treatments that might warrant further study.



CORRIDOR SCORES AND INTERPRETATION

In the regionwide analysis for RED Lanes suitability, this corridor received a score of 7. This suggests that based on the analysis, this segment may exhibit characteristics which constrict transit movement, right turns and driveway access.

Suitability Score	7
Travel Demand Score	6
Highway Operations Score	9
Transit Operations Score	6
Context and Design Score	4

Detailed Differentiators	
Communities of Concern Served	Med
Feasibility	Med
Implementation Guidance	
Nonmotorized propensity	Low
TSP suitability	Med
Full-time suitability	High

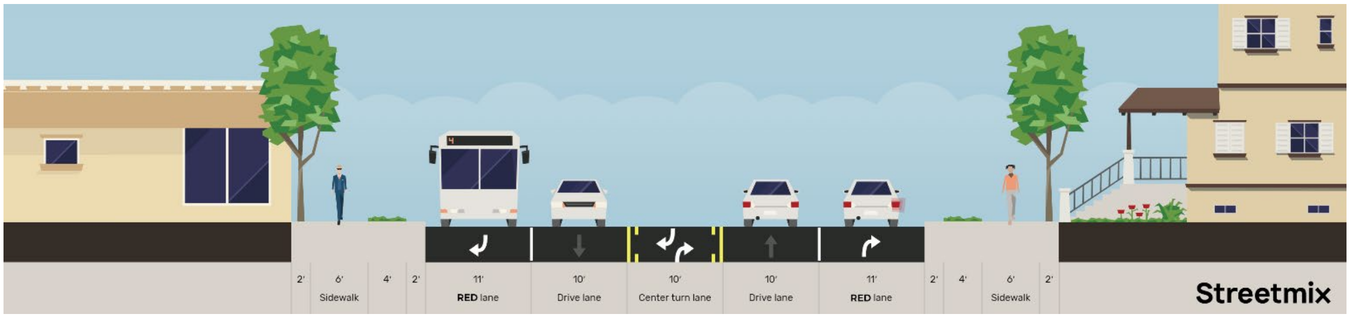
Suitability Score of 7 = Medium/High RED Lanes Suitability Medium to high scores on many parameters observed on this segment. Low scoring parameters may be those with less emphasis in the weighted scoring process. A medium score for *Communities of Concern Served* and *Feasibility* make this segment suitable for a detailed implementation study.

Low non-motorized propensity indicates a low necessity of including bicycle and pedestrian elements in the design. *Medium Transit Signal Priority Suitability* warrants further study into application of TSP system at signalized intersections. *High full-time suitability* warrants application of RED painted bus lane and either a bus mounted or stationary camera for enforcement.

Potential Street Configurations

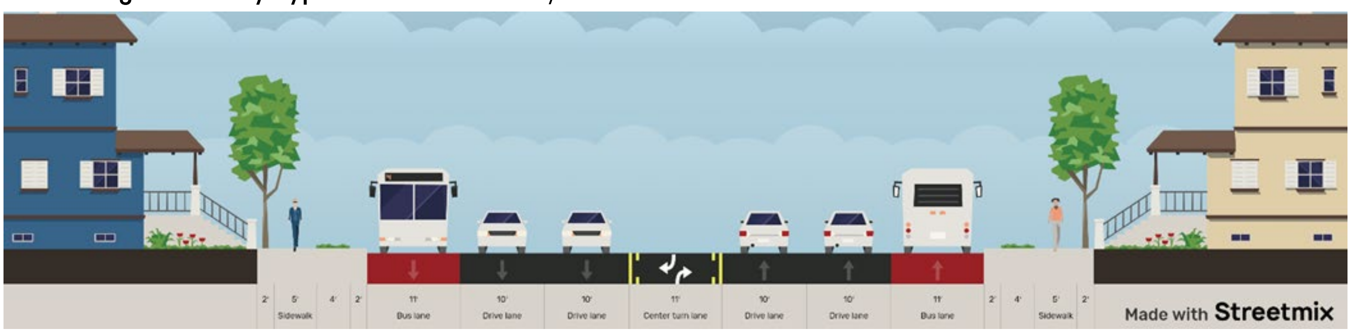
Lower-investment configuration

Potential Section: Type B1 - 5 Lane road with 2 general purpose lanes, 1 center turn lane, and 2 RED Lanes
Lane Type: L1 – Standard Bus Lane – White Pavement Striping | **Enforcement Type**: E2 – Bus-Mounted Camera
Transit Signal Priority Type: T2 – GPS based system



Higher-investment configuration

Potential Section: Type D - 7 Lane road with 4 general purpose lanes, 1 center turn lane, and 2 RED Lanes
Lane type: L2 – RED Paint Bus Lane | **Enforcement Type**: – E2 – Bus-Mounted Camera
Transit Signal Priority Type: T2 – GPS based system



All changes may require additional design and traffic impact studies. Some changes may require NEPA and other studies. In future, an exploration into widening this segment to 6 lanes (with 4 drive lanes, 2 RED Lanes and a median) may be warranted based on traffic volumes in this corridor. That may require additional ROW and shifting of utilities. Cost considerations for such a possibility is beyond the scope of this study.

Sketch-level cost estimates (excluding ROW) for elements that might be considered in further study

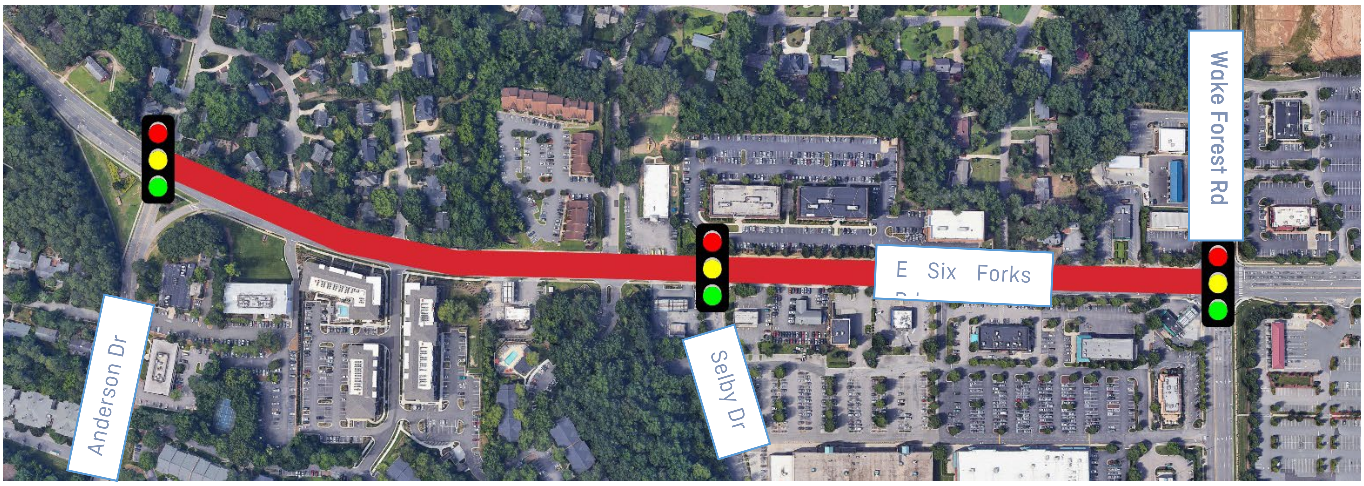
Element	Lower Investment Cost	Higher Investment Cost
Road Widening		$2,000,000
Paint Cost (to be applied every 5 years)	$65,000	$187,000
TSP (10 buses)	$60,000	$60,000
Bus-mounted camera (10 buses)	$95,000	$95,000
Subtotal	$220,000	$342,000
Design + Oversight + Contingency (~50%)	$110,000	$171,000
Total Capital Costs	**$330,000**	**$2,513,000**
Maintenance and Enforcement (every 5 years)	**$54,000**	**$54,000**

This list of elements is not exhaustive. These elements could be employed to enhance the functioning of the corridor in terms of Right Turns, Emergency Vehicles and Driveway Access. Cost estimates only include RED Lanes elements.

CORRIDOR: SIX FORKS ROAD

From Wake Forest Rd to Anderson Dr   Length: 2800 feet   Signalized Intersections: 3
AADT 2018: 24,500

This Corridor Scoping Sheet presents suitability criteria and appropriate potential design, operational, and enforcement elements for a candidate RED Lane corridor. The information on this sheet is intended to help potential project sponsors understand the corridor suitability and range of treatments that might warrant further study.



CORRIDOR SCORES AND INTERPRETATION

In the regionwide analysis for RED Lanes suitability, this corridor received a score of 7. This suggests that based on the analysis, this segment may exhibit characteristics which constrict transit movement, right turns and driveway access.

Suitability Score	7
Travel Demand Score	7
Highway Operations Score	7
Transit Operations Score	7
Context and Design Score	4

Detailed Differentiators	
Communities of Concern Served	Med
Feasibility	Med
Implementation Guidance	
Nonmotorized propensity	Med
TSP suitability	Med
Full-time suitability	High

Suitability Score of 7 = Medium/High RED Lanes Suitability Medium to high scores on many parameters observed on this segment. Low scoring parameters may be those with less emphasis in the weighted scoring process. A medium score for *Communities of Concern Served* and *Feasibility* make this segment suitable for a detailed implementation study.

Medium non-motorized propensity indicates a possibility of including bicycle and pedestrian elements in the design. *Medium Transit Signal Priority Suitability* warrants further study into application of TSP system at signalized intersections. *High full-time suitability* warrants application of RED painted bus lane and either a bus mounted or stationary camera for enforcement.

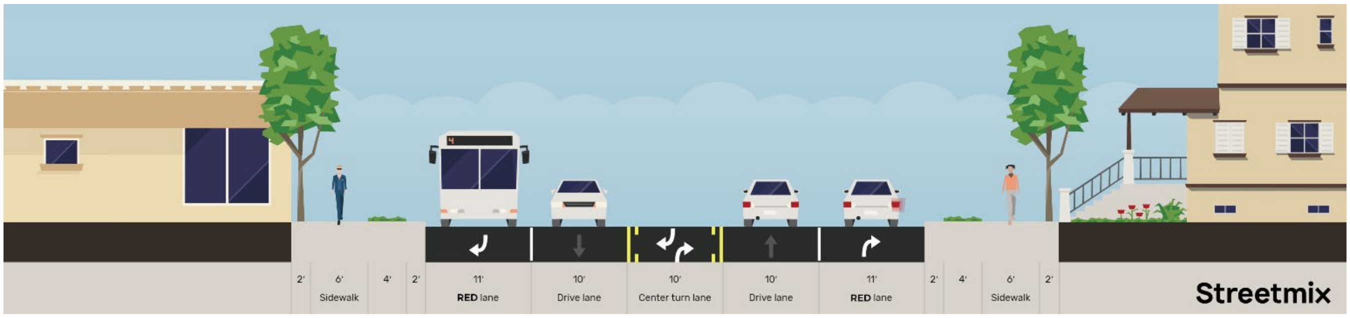
POTENTIAL STREET CONFIGURATIONS

Lower-investment configuration

Potential Section: Type B1 - 5 Lane road with 2 general purpose lanes, 1 center turn lane, and 2 RED Lanes

Lane Type: L1 – Standard Bus Lane – White Pavement Striping | **Enforcement Type**: E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system

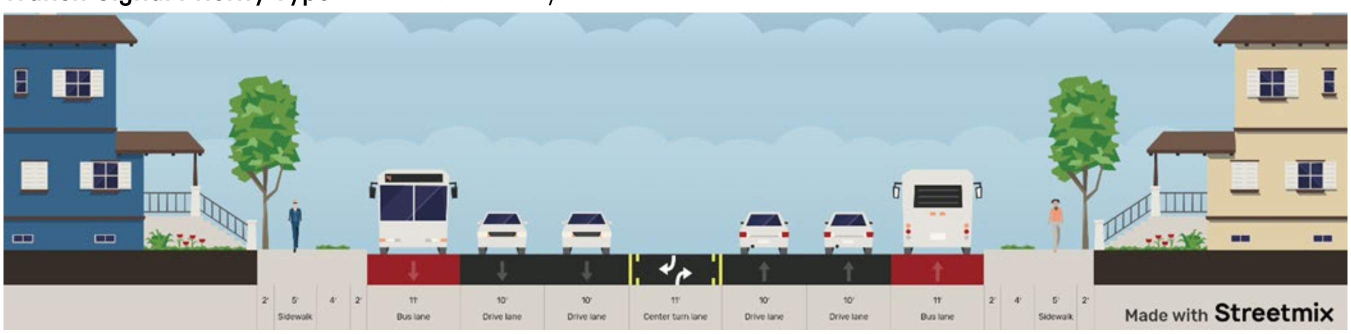


Higher-investment configuration

Potential Section: Type D - 7 Lane road with 4 general purpose lanes, 1 center turn lane, and 2 RED Lanes

Lane type: L2 – RED Paint Bus Lane | **Enforcement Type**: – E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system



All changes may require additional design and traffic impact studies. Some changes may require NEPA and other studies. In future, an exploration into widening this segment to 6 lanes (with 4 drive lanes, 2 RED Lanes and a median) may be warranted based on traffic volumes in this corridor. That may require additional ROW and shifting of utilities. Cost considerations for such a possibility is beyond the scope of this study.

Sketch-level cost estimates (excluding ROW) for elements that might be considered in further study

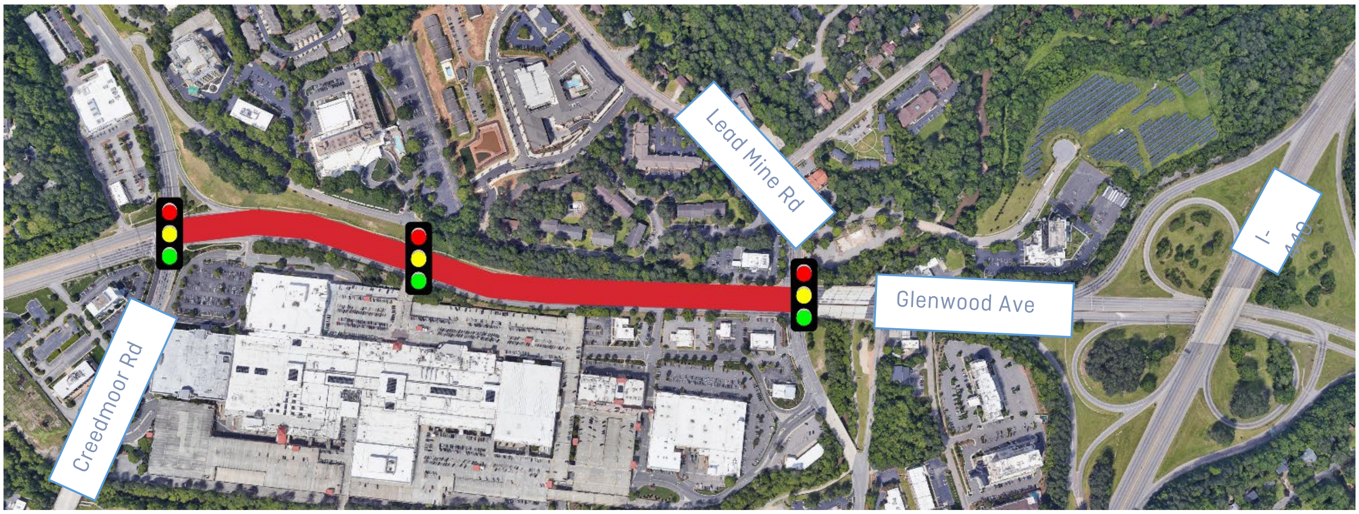
Element	Lower Investment Cost	Higher Investment Cost
Road Widening		$3,200,000
Paint Cost (to be applied every 5 years)	$107,000	$308,000
TSP (10 buses)	$80,000	$80,000
Bus-mounted camera (10 buses)	$95,000	$95,000
Subtotal	$282,000	$483,000
Design + Oversight + Contingency (~50%)	$141,000	$241,500
Total Capital Costs	**$423,000**	**$3,924,500**
Maintenance and Enforcement (every 5 years)	**$65,000**	**$65,000**

This list of elements is not exhaustive. These elements could be employed to enhance the functioning of the corridor in terms of Right Turns, Emergency Vehicles and Driveway Access. Cost estimates only include RED Lanes elements.

CORRIDOR: GLENWOOD BLVD

From Creedmoor Rd to Lead Mine Rd Length: 2650 feet Signalized Intersections: 3
AADT 2018: 51,500

This Corridor Scoping Sheet presents suitability criteria and appropriate potential design, operational, and enforcement elements for a candidate RED Lane corridor. The information on this sheet is intended to help potential project sponsors understand the corridor suitability and range of treatments that might warrant further study.



CORRIDOR SCORES AND INTERPRETATION

In the regionwide analysis for RED Lanes suitability, this corridor received a score of 8. This suggests that based on the analysis, this segment may exhibit characteristics which constrict transit movement, right turns and driveway access.

Suitability Score	8
Travel Demand Score	8
Highway Operations Score	9
Transit Operations Score	9
Context and Design Score	8

Detailed Differentiators	
Communities of Concern Served	Med
Feasibility	Med
Implementation Guidance	
Nonmotorized propensity	Med
TSP suitability	Med
Full-time suitability	High

Suitability Score of 8 = Very High RED Lanes Suitability High scores on many parameters observed on this segment. Low scoring parameters may be those with less emphasis in the weighted scoring process. A medium score for *Communities of Concern Served* and *Feasibility* make this segment suitable for a detailed implementation study.

Medium non-motorized propensity indicates a possibility of including bicycle and pedestrian elements in the design. *Medium Transit Signal Priority Suitability* warrants further study into application of TSP system at signalized intersections. *High full-time suitability* warrants application of RED painted bus lane and either a bus mounted or stationary camera for enforcement.

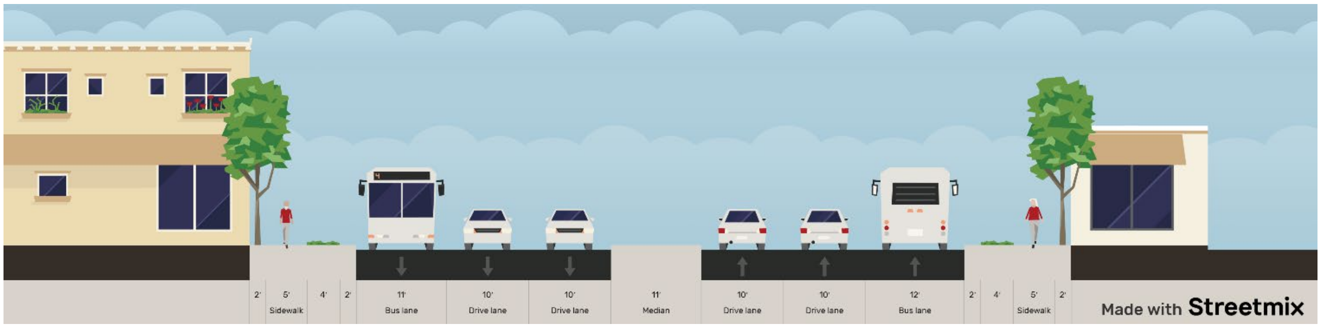
POTENTIAL STREET CONFIGURATIONS

Lower-investment configuration

Potential Section: Type C1 - 6 Lane road with 2 general purpose lanes, 1 median, and 2 RED Lanes

Lane Type: L1 – Standard Bus Lane – White Pavement Striping | **Enforcement Type**: E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system

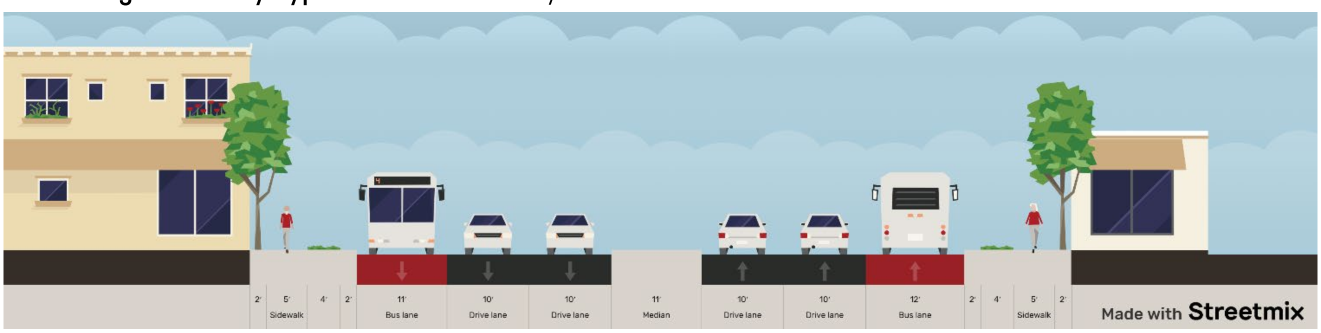


Higher-investment configuration

Potential Section: Type C2 - 6 Lane road with 4 general purpose lanes, 1 median, and 2 RED Lanes

Lane type: L2 – RED Paint Bus Lane | **Enforcement Type**: – E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system



All changes may require additional design and traffic impact studies. Some changes may require NEPA and other studies. In future, an exploration into widening this segment to 8 lanes (with 6 drive lanes, 2 RED Lanes and a median) may be warranted based on traffic volumes in this corridor. That may require additional ROW and shifting of utilities. Cost considerations for such a possibility is beyond the scope of this study.

Sketch-level cost estimates (excluding ROW) for elements that might be considered in further study

Element	Low Impact Section Cost	High Impact Section Cost
Paint Cost (to be applied every 5 years)	$101,000	$292,000
TSP (10 buses)	$80,000	$80,000
Bus-mounted camera (10 buses)	$95,000	$95,000
Subtotal	$276,000	$467,000
Design + Oversight + Contingency (~50%)	$138,000	$233,500
Total Capital Costs	**$414,000**	**$700,500**
Maintenance and Enforcement (every 5 years)	**$63,000**	**$63,000**

This list of elements is not exhaustive. These elements could be employed to enhance the functioning of the corridor in terms of Right Turns, Emergency Vehicles and Driveway Access. Cost estimates only include RED Lanes elements.

Corridor: US 401 Fayetteville Rd

From Manor Ridge to Caddy Rd   Length: 6440 feet   Signalized Intersections: 0
AADT 2018: 32,000

This Corridor Scoping Sheet presents suitability criteria and appropriate potential design, operational, and enforcement elements for a candidate RED Lane corridor. The information on this sheet is intended to help potential project sponsors understand the corridor suitability and range of treatments that might warrant further study.

Corridor Scores and Interpretation

In the regionwide analysis for RED Lanes suitability, this corridor received a score of 8. This suggests that based on the analysis, this segment may exhibit characteristics which constrict transit movement, right turns and driveway access.

Suitability Score	8
Travel Demand Score	7
Highway Operations Score	9
Transit Operations Score	7
Context and Design Score	2

Detailed Differentiators	
Communities of Concern Served	Med
Feasibility	Med
Implementation Guidance	
Nonmotorized propensity	Med
TSP suitability	Med
Full-time suitability	High

Suitability Score of 8 = Very High RED Lanes Suitability High scores on many parameters observed on this segment. Low scoring parameters may be those with less emphasis in the weighted scoring process. A medium score for *Communities of Concern Served* and *Feasibility* make this segment suitable for a detailed implementation study.

Medium non-motorized propensity indicates a possibility of including bicycle and pedestrian elements in the design. *Medium Transit Signal Priority Suitability* warrants further study into application of TSP system at signalized intersections. *High full-time suitability* warrants application of RED painted bus lane and either a bus mounted or stationary camera for enforcement.

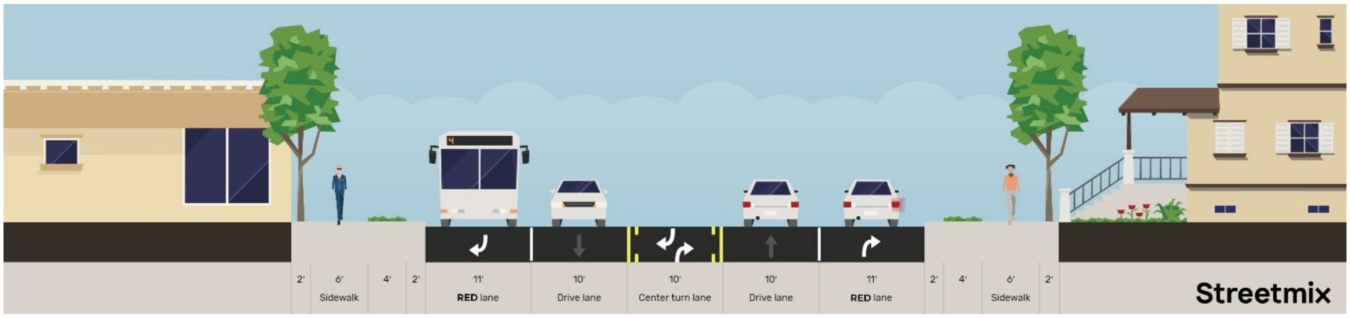
Potential Street Configurations

Lower-investment configuration

Potential Section: Type B1 - 5 Lane road with 2 general purpose lanes, 1 center turn lane, and 2 RED Lanes

Lane Type: L1 – Standard Bus Lane – White Pavement Striping | **Enforcement Type**: E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system

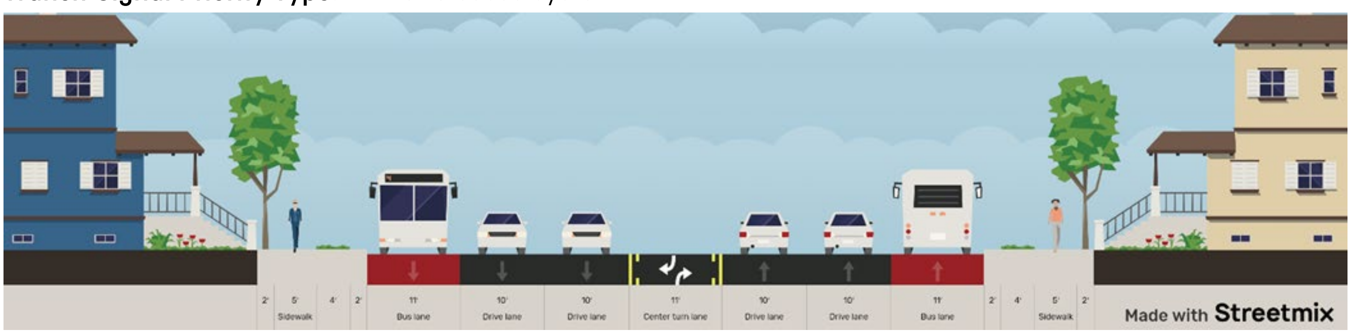


Higher-investment configuration

Potential Section: Type D - 7 Lane road with 4 general purpose lanes, 1 center turn lane, and 2 RED Lanes

Lane type: L2 – RED Paint Bus Lane | **Enforcement Type**: – E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system



All changes may require additional design and traffic impact studies. Some changes may require NEPA and other studies. In future, an exploration into widening this segment to 6 lanes (with 4 drive lanes, 2 RED Lanes and a median) may be warranted based on traffic volumes in this corridor. That may require additional ROW and shifting of utilities. Cost considerations for such a possibility is beyond the scope of this study.

Sketch-level cost estimates (excluding ROW) for elements that might be considered in further study

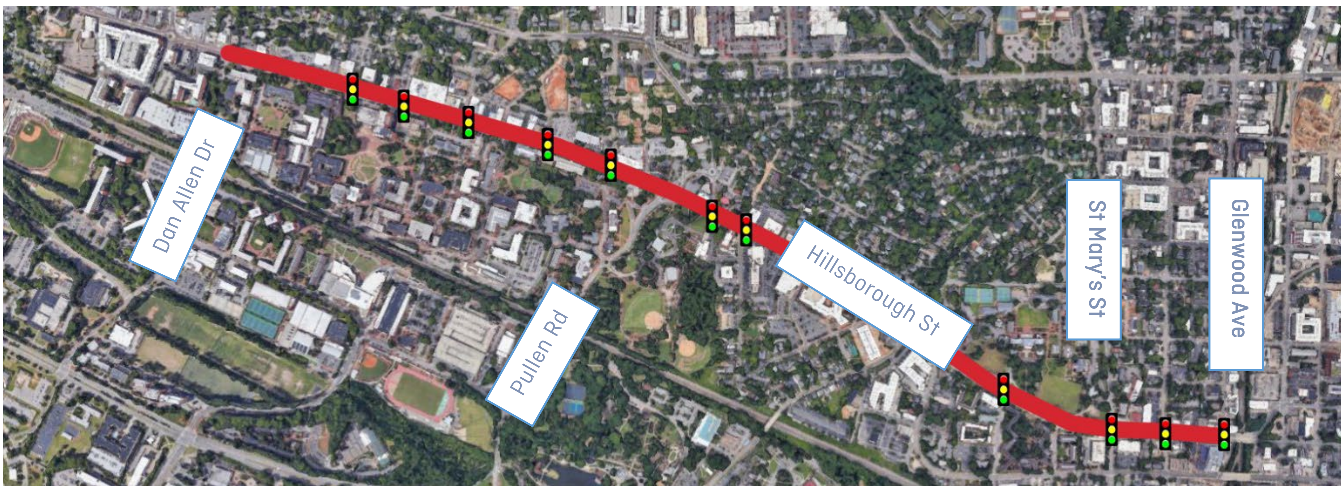
Element	Low Impact Section Cost	High Impact Section Cost
Road Widening		$8,600,000
Paint Cost (to be applied every 5 years)	$244,000	$708,000
TSP (10 buses)	$50,000	$50,000
Bus-mounted camera (10 buses)	$95,000	$95,000
Subtotal	$389,000	$853,000
Design + Oversight + Contingency (~50%)	$194,500	$426,500
Total Capital Costs	**$583,500**	**$9,879,500**
Maintenance and Enforcement (every 5 years)	**$99,000**	**$99,000**

This list of elements is not exhaustive. These elements could be employed to enhance the functioning of the corridor in terms of Right Turns, Emergency Vehicles and Driveway Access. Cost estimates only include RED Lanes elements.

CORRIDOR: HILLSBOROUGH STREET

From Glenwood Ave to Dan Allen Dr   Length: 8600 feet   Signalized Intersections: 11
AADT 2018: 14,000

This Corridor Scoping Sheet presents suitability criteria and appropriate potential design, operational, and enforcement elements for a candidate RED Lane corridor. The information on this sheet is intended to help potential project sponsors understand the corridor suitability and range of treatments that might warrant further study.



CORRIDOR SCORES AND INTERPRETATION

In the regionwide analysis for RED Lanes suitability, this corridor received a score of 8. This suggests that based on the analysis, this segment may exhibit characteristics which constrict transit movement, right turns and driveway access.

Suitability Score	6
Travel Demand Score	5
Highway Operations Score	8
Transit Operations Score	9
Context and Design Score	8

Detailed Differentiators	
Communities of Concern Served	Med
Feasibility	Med
Implementation Guidance	
Nonmotorized propensity	High
TSP suitability	High
Full-time suitability	Med

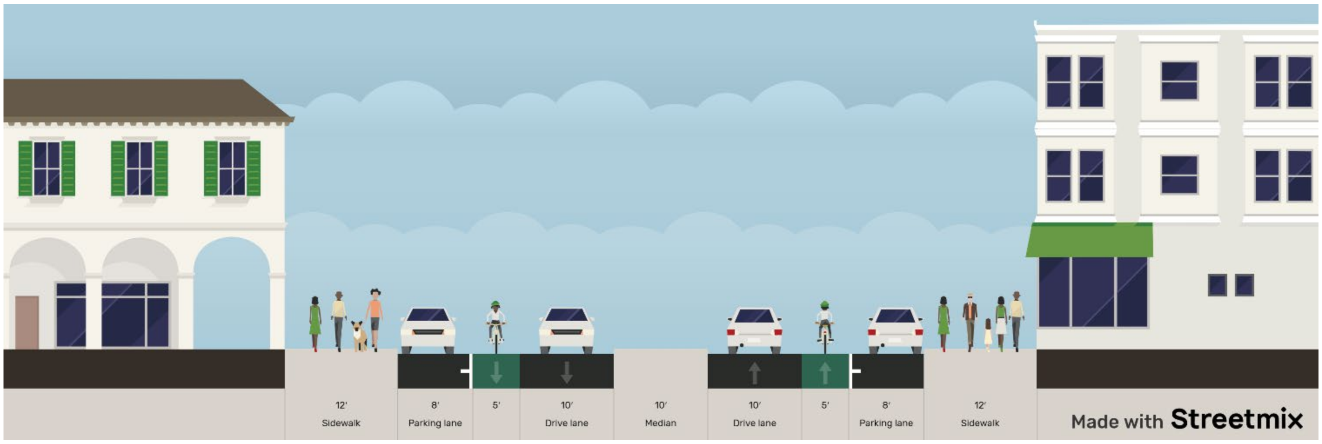
Suitability Score of 6 = Medium/High RED Lanes Suitability High scores on many parameters observed on this segment except travel demand score. Low scoring parameters may be those with less emphasis in the weighted scoring process. A medium score for *Communities of Concern Served* and *Feasibility* make this segment suitable for a detailed implementation study.

High non-motorized propensity indicates a possibility of including bicycle and pedestrian elements in the design. *High Transit Signal Priority Suitability* warrants application of TSP system at signalized intersections. *Medium full-time suitability* warrants further study in application of bus mounted or stationary camera for enforcement.

Potential Street Configurations

Lower-investment configuration

Potential Section: No change in existing road section
Lane Type: None | **Enforcement Type**: None
Transit Signal Priority Type: T2 – GPS based system



All changes may require additional design and traffic impact studies. Some changes may require NEPA and other studies. Cost considerations for additional ROW or reconfiguring the streetscape is beyond the scope of this study

Sketch-level cost estimates (excluding ROW) for elements that might be considered in further study

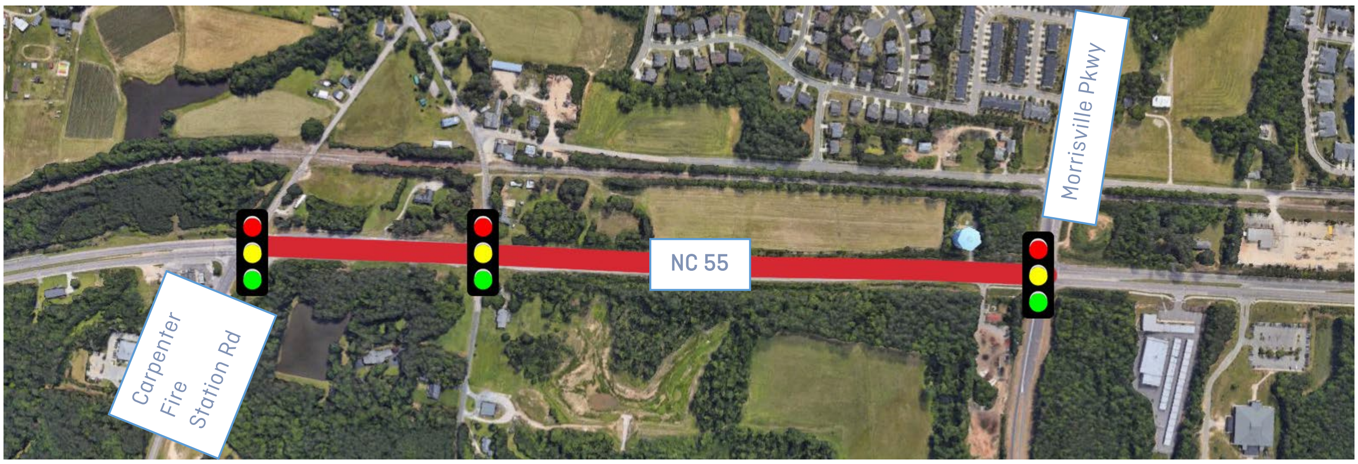
Element	Cost
Paint Cost (to be applied every 5 years)	$0
TSP (10 buses)	$160,000
Bus-mounted camera (10 buses)	$0
Subtotal	$160,000
Design + Oversight + Contingency (~50%)	$80,000
Total Capital Costs	**$240,000**
Maintenance and Enforcement (every 5 years)	**$38,000**

This list of elements is not exhaustive. These elements could be employed to enhance the functioning of the corridor in terms of Right Turns, Emergency Vehicles and Driveway Access. Cost estimates only include RED Lanes elements.

CORRIDOR: NC 55

From Morrisville Pkwy to Carpenter Fire Station Rd
Signalized Intersections: 3
Length: 3500 feet
AADT 2018: 25,500

This Corridor Scoping Sheet presents suitability criteria and appropriate potential design, operational, and enforcement elements for a candidate RED Lane corridor. The information on this sheet is intended to help potential project sponsors understand the corridor suitability and range of treatments that might warrant further study.



CORRIDOR SCORES AND INTERPRETATION

In the regionwide analysis for RED Lanes suitability, this corridor received a score of 8. This suggests that based on the analysis, this segment may exhibit characteristics which constrict transit movement, right turns and driveway access

Suitability Score	6
Travel Demand Score	6
Highway Operations Score	10
Transit Operations Score	3
Context and Design Score	2

Detailed Differentiators	
Communities of Concern Served	Med
Feasibility	Med
Implementation Guidance	
Nonmotorized propensity	Low
TSP suitability	Med
Full-time suitability	Med

Suitability Score of 6 = Medium/ High RED Lanes Suitability low to medium scores on many parameters observed on this segment except highway operations score. Low scoring parameters may be those with less emphasis in the weighted scoring process. A medium score for *Communities of Concern Served* and *Feasibility* make this segment suitable for a detailed implementation study.

Low non-motorized propensity indicates that it may not warrant including bicycle and pedestrian elements in the design. *Medium Transit Signal Priority Suitability* warrants further study into application of TSP system at signalized intersections. *Medium full-time suitability* warrants further study into application of RED painted bus lane and either a bus mounted or stationary camera for enforcement.

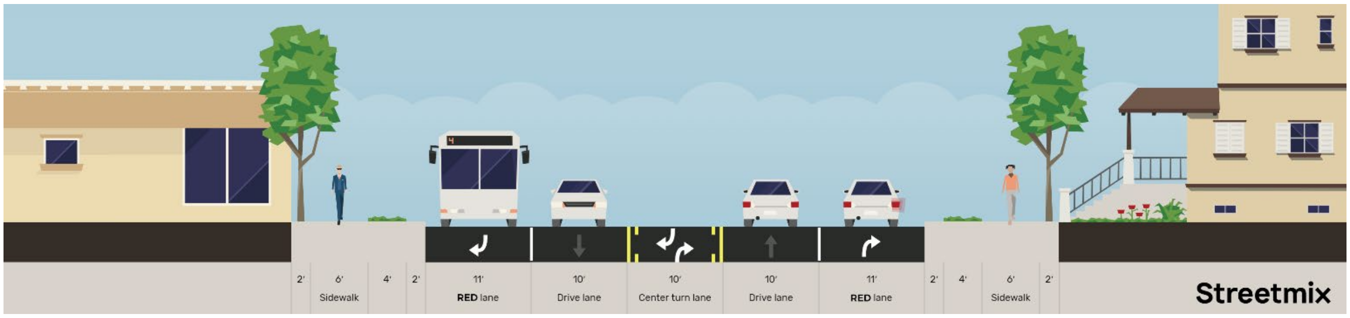
POTENTIAL STREET CONFIGURATIONS

Lower-investment configuration

Potential Section: Type B1 - 5 Lane road with 2 general purpose lanes, 1 center turn lane, and 2 RED Lanes

Lane Type: L1 – Standard Bus Lane – White Pavement Striping | **Enforcement Type**: E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system

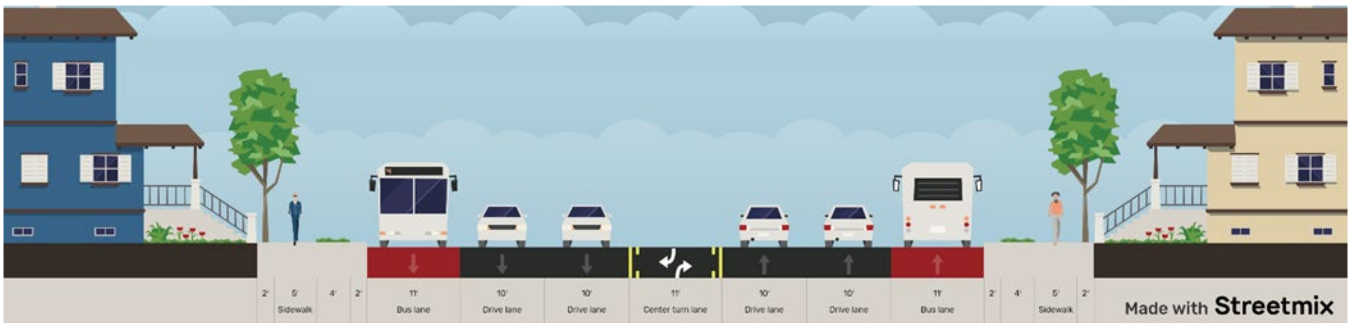


Higher-investment configuration

Potential Section: Type D - 7 Lane road with 4 general purpose lanes, 1 center turn lane, and 2 RED Lanes

Lane type: L2 – RED Paint Bus Lane | **Enforcement Type**: – E2 – Bus-Mounted Camera

Transit Signal Priority Type: T2 – GPS based system



All changes may require additional design and traffic impact studies. Some changes may require NEPA and other studies. In future, an exploration into widening this segment to 6 lanes (with 4 drive lanes, 2 RED Lanes and a median) may be warranted based on traffic volumes in this corridor. That may require additional ROW and shifting of utilities. Cost considerations for such a possibility is beyond the scope of this study.

Sketch-level cost estimates (excluding ROW) for elements that might be considered in further study

Element	Low Impact Section Cost	High Impact Section Cost
Road Widening		$4,700,000
Paint Cost (to be applied every 5 years)	$133,000	$385,000
TSP (10 buses)	$80,000	$80,000
Bus-mounted camera (10 buses)	$95,000	$95,000
Subtotal	$308,000	$560,000
Design + Oversight + Contingency (~50%)	$154,000	$280,000
Total Capital Costs	**$462,000**	**$5,540,000**
Maintenance and Enforcement (every 5 years)	**$71,000**	**$71,000**

This list of elements is not exhaustive. These elements could be employed to enhance the functioning of the corridor in terms of Right Turns, Emergency Vehicles and Driveway Access. Cost estimates only include RED Lanes elements.

Report 1: RED Lanes Fundamentals

RED LANE FUNDAMENTALS

A Technical Overview Report on Transit Priority Lane Treatments

INTRODUCTION AND SUMMARY OF CONTENTS

PURPOSE OF REPORT

The Capital Area Metropolitan Planning Organization (CAMPO) RED Lanes Study is taking a comprehensive look at transit priority lanes as a potential part of the region's approach to enhancing its transportation system to meet growing demand, improve transit operations, and diversify modal options for local and regional travel. RED lanes are sometimes referred to as business access and transit (BAT) lanes or transit priority lanes. These facilities are an increasingly common component of transportation planning and transit investment across the U.S. and around the world. They can be a cost-effective solution for improving transit operations and service reliability.

This report introduces the key concepts and components of RED lanes, with a focus on typical considerations for planning and implementation. CAMPO defines RED lanes as restricted transit lanes that typically also allow automobile use for:

- Right turns,
- Emergency vehicles, and
- Driveway access.

The primary objective of RED lanes is to optimize bus operations in a corridor. This objective aims to maximize transit competitiveness, reliability, and ridership as well as to expand local and regional travel choices through the dedication of right-of-way. RED lanes also aim to minimize disruption to motor vehicle travel by sharing dedicated lanes with turning vehicles and emergency services. The RED acronym highlights these typical characteristics of RED lanes and reflects the frequent application of red surface treatments to distinguish transit lanes from general use traffic lanes.[1] Although the acronym emphasizes the potential for RED lanes to share space with other motor vehicles, bicycles are also sometimes allowed in transit lanes and a variety of design options are available for implementation that may exclude some or all shared users.

This report is an early step in the development and testing of a RED lanes evaluation process for the CAMPO region, focusing on key concepts and best practices from case studies and literature review.

[1] Note the application of red surface treatment is not always appropriate and use of the RED acronym does not imply red surface treatment will be used on all or any corridors in the CAMPO region. Appropriate surface treatments should be considered on a case-by-case basis; this report offers details on the costs and benefits of different lane markings.

The goal of this report is to provide a technical overview of RED lanes, explaining clearly what they are and how they function. This includes outlining typical facility design and vehicle operations on facilities that include RED lanes, highlighting best practices for planning for RED lanes, and offering generalized costs associated with different potential components of RED lanes. The findings of this report will inform later phases of the CAMPO RED Lanes Study, including the development of a RED lanes evaluation/prioritization methodology for ranking corridors in the CAMPO region according to their suitability/readiness for RED lane implementation. It is supported by case study reviews of RED lane planning and implementation efforts in 10 peer areas/corridors and a thorough review of relevant industry and academic literature on transit priority lanes and accompanying operational enhancements.

Finally, this report addresses a variety of topics closely related to RED lanes, including bus rapid transit (BRT), TSP, and queue jumps. Each of these topics provide insight into how transit priority lanes and operational enhancements function. However, this report – like the RED Lanes Study overall – makes no attempt to comprehensively address the details of each of these components or their distinctive relevance to CAMPO corridors. That is, the Study does not attempt to prioritize corridors for BRT implementation or intersections for potential queue jumps, etc. Rather, it focuses on the selective prioritization of transit vehicles in RED lanes with the general expectation that other modes may at appropriate times or under appropriate circumstances also utilize those lanes. Lane restrictions may be complemented by operational enhancements as warranted by corridor characteristics and local/regional planning policy.

Report Structure

Contents

This report is structured to facilitate understanding of RED lanes and key considerations at a glance, while providing additional detail from case studies and literature reviews. This is accomplished by including six “cutaway” pages that serve as handouts for overview information. The cutaway handouts explain:

- What is a RED lane?
- Design Features of RED Lanes
- Bus Operations and Service on RED Lanes
- RED Lanes and BRT
- Best Planning Practices for RED Lanes
- Cost Considerations for RED Lanes

These summary pages have been developed based on a review of transit priority lane applications in peer communities as well as academic and industry literature on transit priority lanes and related subjects. They serve as the “Key Findings” from those efforts. Details of each case study and the reviewed publication are found in the later sections of the report.

RED Lanes Information Gathering Concept Matrix

To help organize information contained in case studies and the reviewed literature, the RED Lanes Information Gathering Concept Matrix was developed. The matrix simply provides a consistent list of topics, for which findings, recommendations, lessons learned, and general information gleaned from case studies or literature review may be organized and recorded. Use of the matrix allows for quick comparisons across case studies and/or publications on diverse topic areas. The matrix includes the following topic areas:

- Demand

- Operations
- Contexts
- Design
- Other Considerations

Each topic area consists of indicators or sub-topics, for which specific information was sought from each case study and publication reviewed. No single case study or publication addressed all topics in the matrix, but collectively, they provide comprehensive insight into the key considerations, costs, benefits, and design alternatives associated with transit priority lanes. Each major topic area is described briefly below, followed by a blank shell of the Information Gathering Concept Matrix.

Demand

The Demand topic area focuses on travel demand considerations associated with effective implementation of RED lanes. Common demand indicators are transit ridership (within the RED lane corridor) and traffic volumes. In rare cases, multi-modal demand indicators such as mode shares, non-motorized user demand, and person throughput are considered. Each of these indicators provides insight into how a facility is being used. Demand metrics may be derived from observed data or model estimates and forecasts. In some cases, time-of-day considerations – such as demand in peak commuting hours – are important.

Operations

The Operations topic area includes indicators describing the experience of traversing a corridor by the transit or auto mode. For transit, indicators include on-time performance (percent of vehicles arriving at a given stop location on-time, e.g.), travel time reliability (consistency of route travel times, e.g.), service frequency, and average vehicle operating speeds. For the auto mode, vehicle or person delay (generally associated with congestion or inefficient operations) is a common indicator. The operations topic area also includes information on TSP, whether it has been implemented or recommended and under what conditions. As with demand consideration, operational indicators may be derived from existing or modeled data, and time-of-day considerations may be significant.

Contexts

Indicators in the Contexts topic area focus on land uses and activity within/adjacent to a corridor. RED lanes can be a major component of complete streets implementation, a context-sensitive facility design approach that accounts for all users in the right-of-way. Usually, adjacent land uses are a prominent consideration in facility design using complete streets principles. Additionally, consideration of nearby businesses and populations can inform transit service design, such as stop spacing or service frequency. Parking for nearby activities – whether on-street or off-street – may need to be accessed by motorists, thereby influencing RED lane design and/or posted restrictions. Finally, corridor functional and access classes may influence RED lane implementation in a corridor. Generally, contextual information should account for local plans and growth strategies in addition to current conditions.

Design

While the above topic areas are potential major informants of a RED lanes evaluation/prioritization approach, the Design topic area pertains more to the appropriate design options and standards for a RED lane in a given corridor. Design indicators include lane width, number of lanes, and intersection design. Notes on these sub-topics can provide insight into the best approach to implementing RED lanes, when to share lane space with other modes, and when to exclude other modes. Design choices are influenced by travel demand, operational, and contextual cues as well.

Other Considerations

Finally, the Other topic area includes a handful of miscellaneous indicators/sub-topics that are important aspects of RED lane planning and implementation. These include safety considerations and when/how these are directly addressed by transit priority lanes or associated improvements; enforcement considerations to maximize the effectiveness of RED lanes in providing expected benefits; maintenance considerations for RED lanes, focusing especially on red surface treatments; and cost considerations to gauge the expected expense associated with a given RED lane project. Project length is also included for case study summaries.

RED LANES INFORMATION GATHERING CONCEPT MATRIX		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	[Key findings listed by topic and indicator]
	Transit Mode Share	[Gray-shaded cells denote topics not covered in detail]
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	
	Transit Signal Priority	
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	
	Intersection Design	
	Separation of Traffic	
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	
	Project length	

What is a RED Lane?

A RED lane is a transit-priority travel lane with restrictions for other modes. While RED lanes restrict non-transit users within the lane, they do not necessarily exclude them. In fact, buses typically share RED lanes with:

- **R**ight turning cars;
- **E**mergency vehicles; and
- **D**riveway access.

The primary objective of RED lanes is to optimize bus operations in a corridor to maximize transit competitiveness, reliability, and ridership through the dedication of right-of-way. RED lanes also aim to **minimize disruption to drivers** by sharing the dedicated lane space with turning vehicles and emergency services. The RED acronym highlights these typical characteristics of the transit priority lanes and reflects the frequent application of red surface treatments to demarcate transit lanes from general use traffic lanes.[2] Although the acronym emphasizes the potential for RED lanes to share space with other motor vehicles, bicycles are also sometimes allowed in transit lanes and a variety of design options are available for implementation that may exclude some or all shared uses. RED lanes are sometimes referred to as business access and transit (BAT) lanes or simply transit priority lanes.

Bus priority lanes can be implemented in a variety of ways and in a variety of contexts. Other users, like bicycles, taxis, and emergency vehicles can use the lanes. Pavement markings, posted speeds, and parking restrictions vary. (Source: Greater Greater Washington)

RED lanes are typically applied in situations where there is a desire or need to **reduce delays associated with congestion**, implement rapid transit improvements along a corridor, or in cases where policy goals seek to **enhance the attractiveness of transit** relative to other modes.

RED lanes can be created through converting an existing traffic lane, eliminating parking, widening a roadway, or utilizing existing unused right-of-way in a median. As noted above, **other non-transit vehicles and users are often allowed in RED lanes**. Non-transit users are typically allowed in RED lanes when transit volumes (ridership and/or service frequencies) are low enough that their presence will not unduly inhibit travel time savings or reliability benefits to transit vehicles or in cases where shared

[2] Note the application of red surface treatment is not always appropriate and use of the RED acronym in no way implies that red surface treatment will be applied on all or any corridors in the CAMPO region. Appropriate surface treatments should be considered on a case-by-case basis.

use of the lane will help reduce implementation costs or achieve other policy goals. Emergency vehicles are always permitted to use RED lanes.

There are several different types of RED lanes, including **numerous design alternatives** to suit corridor-specific conditions and policy objectives. They can be located curbside, offset from the curb (adjacent to on-street parking, e.g.), or in a variety of street configurations that meet special situations or needs. The length of a transit lane can vary. In some cases, a RED lane may run along an entire corridor or bus route. However, it may also be desirable to implement a short RED lane, such as a queue bypass, which allows a transit vehicle to bypass a specific bottleneck. RED lanes can also be targeted to specific sections of a corridor, where transit vehicles frequently are delayed by congestion.

An Interior (Offset) Bus Lane retains parking on the curbside and allows motorists making right turns or maneuvering into/out of parking spaces to utilize the lane. In this example, bicycles are also permitted in the RED lane. (Source: A Guidebook on Transit-Supportive Roadway Strategies)

Intersection designs for RED lanes present additional options. RED lanes can continue through intersections or be dissolved at an intersection approach to accommodate the operational and maneuvering needs of transit vehicles and/or other users, while lane placement varies based on routing and facility attributes. Signal phasing and timing at intersections may also need to be modified. **Transit signal priority (TSP) can enhance the effectiveness of RED lanes** by minimizing transit vehicle delays at intersections.

Numerous studies have found that – used in conjunction with traditional signage and lane markings – **red surface treatments are effective at reducing RED lane violations** by restricted users. While it is important to consider that special permission may be needed from regional transportation partners (such as NCDOT and local jurisdictions) before red surface treatments are implemented, numerous successful case studies and recommendations exist from professional organizations, making this application process feasible for most communities. However, **red surface treatments are not necessary for effective RED lane implementation**, and there are cases in which they are not an appropriate component.

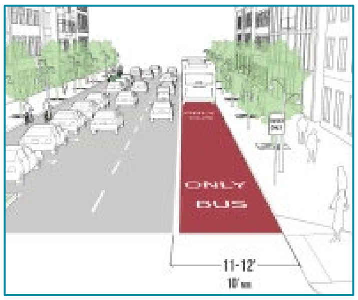
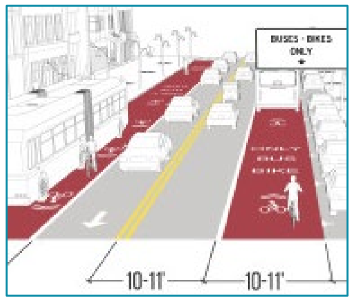
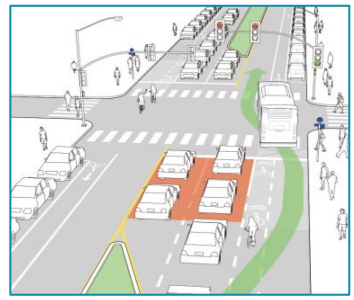
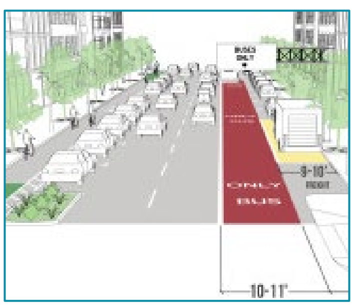
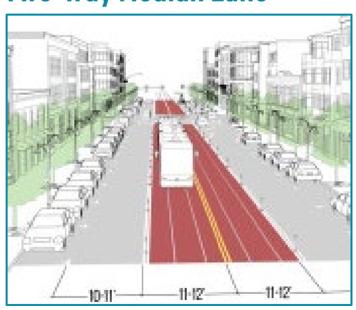
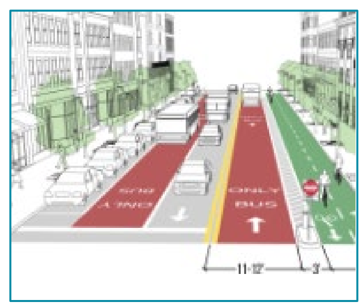
RED lanes are most effective in corridors with high-frequency and high-volume transit routes, while the safety of all travelers, traffic volumes and delay in the corridor, density and diversity of adjacent land uses, urban design characteristics, and policy objectives are also important considerations in planning for RED lanes. **RED lanes offer a relatively low-cost solution to enhancing transit service** and can serve as a pre-cursor to bus rapid transit (BRT)

.

Design Features of RED Lanes

Broadly, RED lanes are transit priority lanes that sometimes allow other users, such as bicyclists or turning vehicles, to share the lane with transit vehicles. Appropriate design of a RED lane varies on a case-by-case basis, depending on transit service, and corridor travel patterns. Several general design options for transit priority lanes are shown below. Designs with bus priority in the median, along the left side of a street, or in a contraflow treatment are inconsistent with the "RED" acronym but may be applicable for other transit priority lanes. They are included to show a range of design options.

Placement on Street

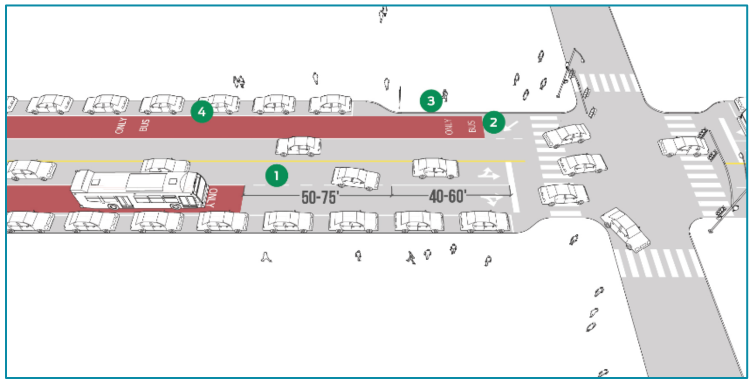
Curbside Lane	Shared Transit/Bicycle Lane	Queue Bypass
		
Curbside lanes are located on the outermost lane of a street. Curbside lanes can be created by converting a parking lane or existing travel lane to a part-time or full-time transit priority lane.	A shared RED lane is typically wider to accommodate shared use with bicyclists and includes bicycle and bus-only markings. These facilities may be used where there is not enough space for separate facilities. for both modes	Queue bypasses are short transit lanes intended to allow transit vehicles to bypass congestion and move to the front of a queue. They may be appropriate at bottleneck locations, usually at intersections.
Offset Lane	**Two-Way Median Lane**	**Contraflow Lane**
		
An offset RED lane is separated from the curb by a lane designed for other uses, including on-street parking, deliveries, or right-turning vehicles. Offset lanes are generally only recommended in situations where the conversion to a transit priority lane is possible while still preserving at least two other travel lanes in the same direction.	This type of transit facility provides an exclusive running way for transit vehicles. It is often implemented for Bus Rapid Transit (BRT) projects. Other users are not permitted in this configuration. Also, transit-only signaling is typically required, increasing the cost and complexity of installations.	Contraflow lanes allow transit vehicles to travel in the opposite direction on a one-way street. They may be an option when two-way transit service is desired on a one-way street, for short legs to make routing more direct, or where high directionality in traffic may allow buses to take underutilized lane capacity in the non-peak direction.
Left-Side Lane	Left-side lanes may be appropriate for express bus routes, areas with large volumes of right-turning vehicles, and when transit routing requires the transit vehicle to make a left turn.	

LANE WIDTH AND SEGMENT LENGTH

In most applications, **10-11 ft. is the minimum width necessary for a RED lane**, with 12-13 ft. considered desirable. In situations where a RED lane is shared with bicyclists, 14.5-16 ft. is needed to allow enough space for both modes to safely coexist. These are general best practices described in various sources. Currently, there are no national or NCDOT standards for RED Lanes.

Although **the greatest benefits of RED lanes are realized when they are designated along an entire corridor** or route, benefits can be realized from applications in short segments. There are numerous examples of RED lanes in short targeted segments, based on evaluations that consider feasibility and/or effectiveness (see Washington DC Georgia Avenue case study, e.g.).

Transit lanes can also be dissolved at intersections, where turning movements may limit their feasibility or reduce benefits. In situations where transit lanes dissolve, companion strategies should be considered, such as queue jumps and transit signal priority (TSP).



A transit lane that dissolves at an intersection (Source: NACTO Transit Street Design Guide)

RED SURFACE MATERIAL

Red surface treatments are effective at reducing violations in RED lanes when accompanied by traditional signage and pavement markings. Research has found that red surface treatments can **reduce violations by 50 percent**, and in some cases even eliminate unauthorized use. Special permission may be needed from appropriate agencies to use red treatments to designate RED lanes. Application template letters and case studies are provided in relevant documents reviewed for this report.

It is best practice to utilize a red surface treatment only in situations where RED lane restrictions apply on a full-time basis (i.e., when transit frequencies and ridership are high throughout the day). **Allowing non-transit vehicles to use red-colored lanes during parts of the day reduces their effectiveness.** Some areas have chosen to apply a red color treatment only once, when a transit lane is first designated, with the intent to raise awareness of the new facility. As the red treatment fades, traditional signage and lane markings can be utilized to maintain compliance with restrictions that are in place.

BULB OUTS

Bulb outs, or curb extensions, expand the sidewalk to the edge of the parking lane, reducing delays related to stops by allowing buses to stop in the travel lane. Curb extensions are best suited for areas with high-density development and where on-street parking is present.

A bus bulb out, also known as a curb extension. (Source. NATCO Transit Street Design Guide)

Bus Operations and Service on RED Lanes

RED lanes prioritize transit vehicle operations to reduce travel times and improve reliability. Their effectiveness and appropriateness depend in part on the supply and demand of transit service in a corridor. As transit service and performance often varies by time of day, RED lane restrictions can be implemented on a full-time or part-time basis. Additionally, other users are often permitted to share the lane with transit vehicles. Finally, companion strategies like transit signal priority (TSP) can be implemented to improve operations in a corridor.

Typical Transit Service Characteristics on RED Lanes

Generally, **transit service should be frequent enough that lane restrictions are effectively self-enforcing.** In cases where bus volumes may not be high enough to accomplish this, lane utilization can be enhanced by allowing other users to share the RED lane, such as bikes, taxies, and right-turning vehicles. While some publications have suggested a minimum of 10 transit vehicles per hour on priority lanes, there is no definitive quantity of service criterion justifying or precluding their implementation.

Duration of Restrictions

RED lanes can be operated on a full-time or part-time basis. **Full-time RED lanes should maintain reasonably frequent service throughout the day.** If this is not feasible or justified by transit demand, part-time RED lanes may still be appropriate. In a part-time scenario, all vehicles may be allowed in the RED lane at off-peak hours. In cases where a RED lane is designated with red surface treatment, lane restrictions should be implemented on a full-time basis, as **allowing all vehicles to use red-treated lanes during parts of the day can reduce their effectiveness**.

Shared Users

Transit vehicles may share RED lanes with other users, even when restrictions apply on a full-time basis. Other users that may be permitted include right-turning vehicles, taxis, delivery vehicles, parking vehicles (in an offset-lane, e.g.), bicycles. **The travel time benefits to transit vehicles are greatest when no other users are allowed.** For example, allowing right-turning vehicles in transit lanes reduces the time-savings benefit that transit vehicles receive by half.

A Shared Bus-Bike Lane in Boston, MA (Source: NACTO)

Shared users should be considered in situations where transit volumes and speeds are relatively low or where allowing other users supports broader policy goals. When other users are allowed, RED lane design approaches should account for the shared users and ensure all modes are accommodated safely and comfortably. For example, if bicycles are allowed, wider lanes should be used with conventional bike-lane striping or other markings to clearly delineate space for bicycle and vehicular traffic to allow for safe passing maneuvers. If right-turning vehicles are allowed, strategies such as access management or implementing queue jumps at intersections should be considered to mitigate the impact on transit vehicle speeds.

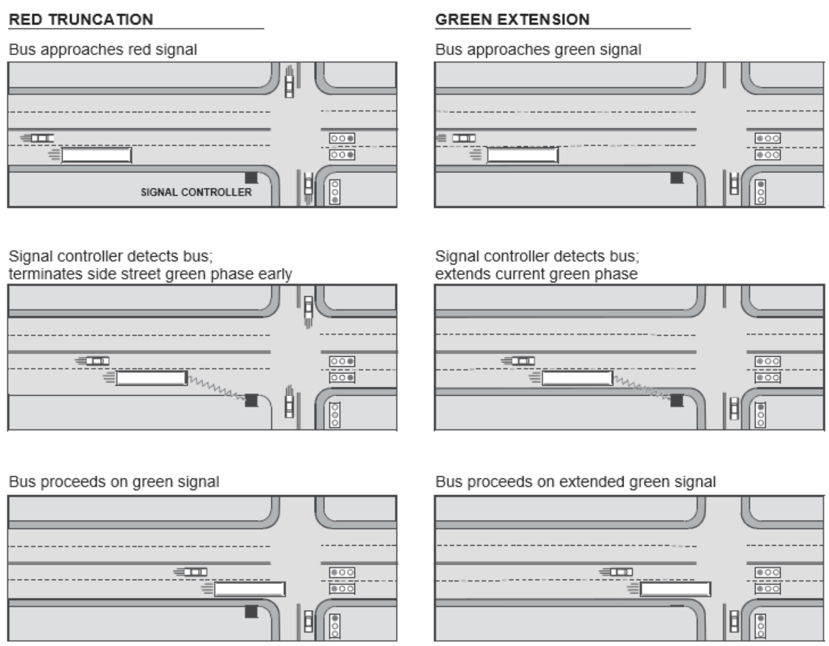
Emergency vehicles have the right to utilize all available lanes during an emergency, and **RED lanes can provide space for first responders to bypass traffic in general use lanes, especially in congested corridors.**

Transit Signal Prioritization

Transit Signal Prioritization (TSP) is a method for increasing transit vehicle speed and improving reliability through the adjustment of signal timing at intersections. **TSP typically extends a green phase or truncates a red phase if a transit vehicle is attempting to enter an intersection**, thereby decreasing the delay likely to be experienced at a signalized intersection. Unlike signal preemption, TSP does not override a signal. Rather, it changes the length of the green phase at a signal to optimize transit operations.

TSP can be applied in a variety of contexts, such as along an entire corridor that is suitable or at a specific signalized intersection where TSP will benefit operations. It can be deployed in corridors where transit vehicles operate in mixed traffic or as a companion to RED lane or BRT projects. TSP can significantly improve travel time benefits for transit vehicles in dedicated running-way.

TSP is generally most effective in corridors and intersections where transit vehicles experience delays, but where congestion is not so high that the vehicle cannot take advantage of an early or late green cycle. More specifically, general characteristics of intersections suitable for TSP include:



This diagram illustrates the concept of extending green cycles and truncating red cycles that can be applied with transit signal prioritization (TSP) (Source: TCRP Synthesis 83: Bus and Rail Transit Preferential Treatments in Mixed Traffic)

- Peak intersection volume/capacity (v/c) ratio between 0.6 and 1
- High transit ridership (existing or future)
- Approximately four or more buses per hour
- Intersections with far-side bus stop (or the potential to relocate stop to far side) – stops on the near side of the intersection force buses to stop for passenger boarding/alighting before taking advantage of green time.
- Corridors with long signal cycles and/or long distances between signaled intersections

Queue bypasses can help improve the impact of TSP at intersections with higher levels of congestion and v/c ratios above 1. TSP technology adjusts traffic signal timing when a bus is present at an intersection to give priority to the transit vehicle. A queue jump adds to the benefits of TSP by allowing a bus to move ahead of stopped vehicles. The transit vehicle can then reach the intersection and trigger the adjusted signal phase sooner.

RED LANES AND BRT

Bus Rapid Transit (BRT) is defined by the Federal Transit Administration (FTA) [3] as "a high-quality bus-based transit system that delivers fast and efficient service that may include dedicated lanes, busways, traffic signal priority, off-board fare collection, elevated platforms and enhanced stations." **Transit priority lanes, including RED Lanes, can be integrated into BRT projects where appropriate, or may stand alone as suitable treatments fully independent of BRT considerations.**

BRT projects can be defined as either Fixed-Guideway BRT or Corridor Based BRT. Fixed-Guideway BRT projects must include a dedicated lane for transit vehicles during peak traffic periods for at least 50% of the BRT corridor length. **Both Fixed-Guideway and Corridor Based BRT projects often include a variety of transit priority design treatments** that vary from segment to segment and are customized to the needs and constraints of each segment.

The table below demonstrates the **differences between BRT, Red Lanes, and other transit priority lanes** for several notable design and operations treatments to highlight the differences between these bus priority treatment concepts. Some key differences and commonalities among the three types of bus priority treatments can be summarized as follows:

- The RED Lanes concept, encompassing right turns, emergency vehicles, and driveway access, embodies three elements that are incorporated by definition into the acronym.
- Based on the acronym definition, certain types of design with bus priority in the median, along the left side of a one-way street, or in a contraflow treatment are not applicable for RED Lanes but may be applicable for BRT and for other transit priority lanes.
- In North Carolina (and most jurisdictions nationwide) emergency vehicles are allowed access into bus priority treatment areas by law.
- BRT systems (both Fixed-Guideway and Corridor Based) are defined in large part by service characteristics including service frequency, transit signal priority, and defined stations that including passenger amenities beyond those associated with typical bus stops.
- The majority of treatments are shown in the table as "occasionally", which means that the element described is not required by definition or law for that treatment, nor is it generally found in the literature to be a typical treatment.

In summary, **project characteristics that would be required for federal funding of BRT projects are not as formally defined in RED Lanes or other transit priority lanes**. However, all three of these bus priority treatment options seek to improve transit service performance in corridors where multimodal demand warrants their consideration. The consideration of appropriate transit priority lane treatments within the CAMPO region therefore benefits from an appreciation of the design elements and lessons learned from case studies across all three treatments.

[3] https://www.transit.dot.gov/research-innovation/bus-rapid-transit

Transit supportive element	Fixed-Guideway Bus Rapid Transit	Red Lanes	Other transit priority lanes
DESIGN			
Transit lane presence	Typically	Yes	Yes
Right side of roadway	Occasionally	Yes (By definition)	Typically
Median of roadway	Typically	No	Occasionally
Left side of roadway	Occasionally	No	Occasionally
Contraflow	Occasionally	No	Occasionally
Physically separated from adjacent lanes	Typically	No	Occasionally
Marked by special pavement color or treatments other than pavement marking	Occasionally	Typically	Occasionally
Enhanced stations	Typically	Occasionally	Occasionally
OPERATIONS			
Transit lane shared by			
Right turn vehicles	Occasionally	Yes (By definition)	Occasionally
Emergency vehicles	Yes (By law)	Yes (By law)	Yes (By law)
Driveway access	Occasionally	Yes (By definition)	Occasionally
Private shuttles/taxis	Occasionally	Occasionally	Occasionally
Bicycles	Occasionally	Occasionally	Occasionally
Frequent bi-directional peak period and weekend services	Yes	Typically	Typically
Transit signal priority	Typically	Occasionally	Occasionally
Off-board fare collection	Typically	Occasionally	Occasionally
Route/vehicle "branding"	Typically	Occasionally	Occasionally

Yes Typically Occasionally No

Best Planning Practices for RED Lanes

RED lanes and related projects can be complex. The following best practices help ensure project success.

Building Partnerships and Engagement

Transit-supportive treatments, including RED Lanes, can be complex projects that require coordination between multiple entities. In many cases, roadway and transit agencies, local and state governments, enforcement entities, and stakeholders may be involved at various steps in a project. In some situations, state or local laws may need to be changed. Therefore, **it is important to develop partnerships among agencies and conduct public engagement early and often**. In some cases, agencies and institutions may have competing goals, so it is important to identify this early and address potential differences. One strategy to build partnerships is to focus on developing open lines of communication. Doing so allows information to be shared, such as data and analysis, which can help overcome obstacles and build momentum.

Have a Clear Policy Framework

Transit-supportive treatments are made within a specific local policy environment. A policy framework establishes local planning goals and informs project priorities and appropriate implementation approaches. While transit-supportive facilities are easier to implement within policy frameworks that encourage multi-modal transportation, a variety of strategies can help projects move forward in less supportive policy environments. *TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies*[4] identifies four example policy scenarios and suggests different approaches for working within them. The table below, adapted from the guidebook, can be helpful in identifying a local policy scenario and calibrating an approach.

Scenario	Scenario Description	Transit-Supportive Strategies/Approaches	Evaluation Metrics Typical in Scenario
Maintain Existing Motorized Vehicle Operations	Transportation policies focus on maintain existing motor vehicle operations. Little flexibility permitted for transit-supportive strategies.	Prioritize strategies that require low levels of coordination with highway agency.	N/A
Maintain or Improve (Reduce) Person Delay	Transportation policies focus on reducing per person delay and will consider negative impact on auto if there is net reduction in per person delay.	Pursue approaches that reduce person delays and have minimal impact on auto operations in addition to operations strategies that require limited coordination.	Person Delay by Mode Net Reduction in Person Delay
Maintain Operations at or Above Standard	Transportation policies seek to maintain Level of Service (LOS) and volume-to-capacity ratio (v/c). Degraded auto conditions allowed if minimum thresholds are met.	Many transit-supportive strategies could work. Emphasize strategies that focus on less congested roadway segments.	Level of Service (LOS) Volume-to-Capacity ratio (v/c)
Favor Transit Service	Transportation policies factor transit service above other modes, especially on designated corridors	Transit-supportive strategies are easiest to implement in this environment.	Safety, capacity, access, parking, transit frequency, and cost/benefit

[4] *TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies*. Transportation Research Board (TRB), 2016. https://www.nap.edu/download/21929

Focus on Key Metrics and a Simple Analysis Approach

Given an understanding of a specific policy environment, **a narrow set of key factors may be defined to inform decision-making and reflect policy goals**. In the transit priority treatments literature, there is a set of common considerations when analyzing priority lanes and related improvements. While this list is not comprehensive, it provides a sound foundation for RED lanes planning analyses.

- Transit vehicle volume
- Person throughput (by all modes)
- Automobile level of service (LOS)/delay
- Volume-to-capacity ratio (v/c)
- Reliability/travel time variability
- Safety concerns
- Available right-of-way (ROW)
- Physical/spatial considerations (parking, access, right turns)

It may not be feasible to evaluate all projects or corridors based on every measure chosen. **A tiered approach can make a larger analysis more feasible by filtering out potential candidate corridors in phases**. For example, a 2015 analysis in Baltimore used a tiered approach to filter candidate corridors. The table below, adapted from a publication reviewing the analysis, identifies metrics used in each phase.[5]

Analysis Phase	Performance Measures Used
Candidate Street Identification	Transit Frequency, transit ridership, travel time delay, reliability
Preliminary Criteria	Level of bus service planned, person throughput by mode
Detailed Screening	Person throughput, person delay, volume (pear hour, peak direction), passengers per hour, travel time, average speed, level of service (LOS), volume-to-capacity (v/c), population near corridor, transit-dependent population near corridor, connectivity/transfers, emergency route, freight route, lane width, right turns at intersections
Full Analysis	Traffic operations analysis, including Synchro models, evaluating delay on automobile traffic, identifying impact on LOS and v/c metrics

Implementation and Operations

Agency coordination in RED lane implementation can be facilitated through a memorandum of understanding (MOU). An MOU can discuss roles and responsibilities relating to planning, design, construction, maintenance, and enforcement of new transit-supportive facilities. Specific guidance for developing interagency agreements can be found in *TCRP Legal Research Digest 42: Transit Agency Intergovernmental Agreements: Common Issues and Solutions (Thomas 2012).*

[5] *Developing Dedicated Bus Lane Screening Criteria in Baltimore, Maryland.* Transportation Research Record, 2018. https://journals.sagepub.com/doi/abs/10.1177/0361198118797827

Cost Considerations for RED Lanes

Capital and operations costs for many transit-supportive facilities will depend on design considerations and local conditions. The most accurate estimates for project budgeting should be made through obtaining capital, operations, and maintenance unit costs from local governments and state DOTs. This section provides general guidelines for high-level cost estimates for RED lanes and supporting treatments based on a review of prior projects and literature.

Capital Costs

Capital costs for a RED lane can vary widely based on local and regional contexts and the nature of transit-supportive treatments being considered. The table below highlights planning-level cost estimates identified in the literature for the capital cost of various transit priority improvements.

Transit Lane Treatment	Capital Cost
Transit Priority Lane	
Conversion of existing lane (re-striping and signage)	\$50,000 to \$100,000 per mile (2010 dollars, TCRP 83[6]) \$200,000 per mile (2015 dollars, Miami study[7])
Curb or off-set lanes	\$2 to \$3 million/lane-mile (2007 dollars, TCRP 83)
Median transitway (bus)	\$5 to \$10 million/lane-mile (2007 dollars, TCRP 83)
Standard Surface Paint	\$7.50 per Sq. Yd. (2015 dollars, GRTC Report[8])
High Friction Epoxy Coating	\$28.50 per Sq. Yd (2015 dollars, GRTC Report)
Pigmented / Color Aggregate Asphalt (Red)	\$42.30 per Sq. Yd (2015 dollars, GRTC Report)
Transit Signal Priority	
Transit Signal Priority (TSP) - upgrade existing hardware	\$5,000 or less per intersection (2010 dollars, TCRP 83)
Transit Signal Priority (TSP) - new hardware	\$20,000-\$30,000 per intersection (2010 dollars, TCRP 83)
Enforcement	
Enforcement – Automated Camera	\$130,000-143,000 (2017 dollars) per enforcement camera (MWCOG)[9]
Other Supporting Treatments	
Curb Extension	\$40,000 to \$80,000 each in San Francisco (2010 dollars, TCRP 83)
Queue Jump (utilizing existing roadway)	Signing and striping costs: \$500 to \$2,000 (2010 dollars, TCRP 83). Video or loop detection: \$5,000 to \$15,000 (2010 dollars, TCRP 83) *Note: If new lane is required, costs will vary widely.*

[6] *TCRP Synthesis 83: Bus and Rail Transit Preferential Treatments in Mixed Traffic*. Transportation Research Board (TRB), 2010. https://nacto.org/docs/usdg/tcrp_synthesis_83_danaher.pdf

[7] *Bus Lanes in Downtown Miami: Final Report*. Miami Dade TPO, 2015. http://miamidadetpo.org/library/studies/downtown-miami-bus-lanes-final-report-2015-12.pdf

[8] *GRTC Bus Rapid Transit Project Geotechnical and Pavement Modifications Report,* RK&K/KimleyHorn. 2015. http://ridegrtc.com/media/annual_reports/GRTC_BRT_Geotech_Pavement_Mod_Report_Version_3.0.pdf

[9] Bus Lane Enforcement Study. Metropolitan Washington Council of Governments (MWCOG), 2017. https://www.mwcog.org/assets/1/28/10062017_-_Item_12_-_DO_NOT_PRINT_-_Bus_Lane_Enforcement_Study_Final_Report.pdf

Operating and Maintenance Costs

In additional to capital expenses, **transit-supportive treatments often add operational and maintenance costs**. At the same time, it is important to consider that there can also be savings associated with transit-supportive features, specifically relating to transit vehicle travel times and reliability, which in turn may reduce costs. The table below identifies general guidance and estimates identified in literature for operational and maintenance costs.

Treatment	Operations and Maintenance (O&M) Cost Considerations
Transit Priority Lane	
Transit lane (conversion from existing lane)	**Negligible incremental operating and maintenance costs**; more frequent maintenance probably due to greater wear and tear associated with bus operation. [10]
Transit lane (new lane)	O&M costs typically **under $10,000 per lane-mile per year** (based on national average O&M costs for arterial streets). Most transit agencies have fully allocated or marginal O&M cost models that have vehicle hours and peak vehicle requirements as primary input. Analysis of revenue service travel speeds and times is necessary to determine the degree to which these would decrease as the result of the bus lanes. [11]
Red surface treatment	• Depending on the material used, red surface treatments need to be re-applied after their expected life cycle. In general, **red paint lasts approximately 3-5 years**. More expensive materials can last longer.[12] • A 2017 benefit-cost analysis prepared by MWCOG estimated red lane surface treatment maintenance costs at **$10,000 per mile**. (2017 dollars, MWCOG) [13] • Red treatments generally improve bus travel times and reduce delays, resulting in time savings. However, little data exists on quantifying savings.[14]
Transit Signal Priority	
Transit Signal Priority (TSP)	Maintenance costs vary based on the implementation, including whether existing or new hardware is required. **Roadway agency and transit agency maintenance costs are likely to increase**. Additionally, staff training will likely be needed. [15]
Enforcement	
Enforcement – Police	**$49.50 per hour** (2017 dollars, MWCOG) [16]
Enforcement - Cameras	Costs vary depending on circumstances, but can be expected in the range between **$15 for bus-mounted cameras to $415 per week for stationary cameras** (2017 dollars, MWCOG)

[10] *TCRP Synthesis 83: Bus and Rail Transit Preferential Treatments in Mixed Traffic*. Transportation Research Board (TRB), 2010. https://nacto.org/docs/usdg/tcrp_synthesis_83_danaher.pdf

[11] ibid

[12] Primer on Transit Lane Conspicuity Through Surface Treatment. Transportation Association of Canada, 2010. https://www.tac-atc.ca/sites/tac-atc.ca/files/site/doc/resources/primer-transit-conspicuity2010.pdf

[13] Bus Lane Enforcement Study. Metropolitan Washington Council of Governments (MWCOG), 2017. https://www.mwcog.org/assets/1/28/10062017_-_Item_12_-_DO_NOT_PRINT_-_Bus_Lane_Enforcement_Study_Final_Report.pdf

[14] TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies, 2016. https://www.nap.edu/download/21929

[15] Bus Lane Enforcement Study. Metropolitan Washington Council of Governments (MWCOG), 2017. https://www.mwcog.org/assets/1/28/10062017_-_Item_12_-_DO_NOT_PRINT_-_Bus_Lane_Enforcement_Study_Final_Report.pdf

[16] ibid

Case Studies

RED lanes and similar transit priority treatments are increasingly seen in cities across the U.S. and around the world. They are broadly seen as a cost-effective solution to making transit travel times competitive with auto travel times, enhancing on-time performance and travel time reliability for transit vehicles and riders, and implementing complete streets solutions that enhance safety, comfort, and efficiency for all users of a facility.

This section summarizes 10 case study examples of transit priority lanes in peer regions in the U.S. The case studies provide real-world examples of how transit priority treatments have been implemented in other areas, how they have performed, and how they have been received by the traveling public. Collectively, they contribute to an understanding of best practices for RED lanes planning and implementation, offering lessons learned from direct experience.

The selection of case study projects and communities was informed by several factors. First, projects were selected from "peer" areas. This means that the contexts in which a transit priority treatment was implemented are similar to the contexts in which they are most likely to be deployed across the CAMPO region. At a corridor level, density and diversity of development in the project vicinity was considered; at the regional level, regions with auto-oriented development patterns, high growth rates, and regional population figures similar to CAMPO were generally considered. In some cases, regions with notably larger or smaller populations were included to demonstrate the potential for RED lanes in areas of varying size and urbanization levels. Generally, the case studies show RED lanes can be an appropriate and effective regional mobility strategy in regions of all sizes.

Additionally, the case studies include examples of transit priority lanes as well as bus rapid transit (BRT). The inclusion of BRT projects is helpful because they often incorporate transit priority treatments like exclusive or restricted bus lanes to enhance travel times and ensure reliability of service. RED lanes can offer similar benefits. Moreover, BRT has been identified as an important transit technology option for increasing multimodal travel choices in the CAMPO region, and RED lanes may serve as a component of BRT implementation or a stepping stone toward BRT implementation in certain corridors. Finally, in many cases, the transit priority treatments implemented for BRT bring advantages to other fixed route services that utilize (portions of) the same corridors. Thus, BRT treatments – especially priority transit lanes and transit signal priority (TSP) – can provide benefits to multiple routes.

A brief outline of the case studies included in this section is provided below, followed by the details of each case study under its respective heading. Three case studies were selected for detailed review based on the similarity of issues and/or analysis needs relative to the RED Lanes Study, and these are addressed first. The remaining seven case studies are shorter and follow in alphabetical order.

1. **Richmond (Pulse BRT)** – This project includes corridor treatments supporting implementation of a BRT line, with design variations highlighting alternative approaches to implementation and including TSP and queue jumps at select locations. The Richmond region is similar in size to the CAMPO region with similar transportation infrastructure and transportation policy history.
2. **Orlando (LYMMO)** – This collection of bus priority lanes in Downtown Orlando facilitates connections among transit, work and entertainment destinations, and parking facilities throughout the area. Dedicated bus lanes preserve bus reliability in a congested area. LYMMO offers a potential model for

addressing transit connectivity needs in Downtown Raleigh and other urban centers in the CAMPO region.

3. **Baltimore (dedicated bus lanes)**– As part of a regional system overhaul, Maryland MTA created dedicated bus lanes on multiple urban corridors. The majority of the dedicated bus lanes are shared with bicycles, and in cases where they run adjacent to on-street parking, motorists can use the lane while maneuvering into or out of a parking space. There is currently one localized case where the bus lane restrictions are only in force for select hours of the day, and turning vehicles are also allowed to use the lane. Emergency vehicles are always permitted to utilize the bus lanes as needed. The case study provides examples of alternative designs relative to parking and time-of-day restrictions.
4. **Albuquerque (ART)** – Example of BRT implementation in a smaller region with typical activity densities in transit-supportive corridors similar to the CAMPO region. Service near a sizeable university (UNM). Delayed start to service due to limited range of purchased electric vehicles.
5. **Cleveland (Health Line BRT)** – Well-studied BRT implementation, demonstrating median-running transit lanes with strong ridership and development stimulation. The line has faced TSP and fare enforcement challenges that suppress travel time benefits.
6. **Eugene (EmX)** – Example of BRT implementation in smaller region with similar typical activity densities in transit-supportive corridors similar to the CAMPO region. Portions of dedicated lanes include landscaping and a central grass strip straddled by buses, demarcating the bus-only space. On some one-way streets, the bus lane is in a center exclusive lane, allowing right-turning vehicles to utilize the curbside lane.
7. **Jacksonville (Southeast Corridor)** – Example of short segments (small percentages of route alignments) utilizing bus priority lanes to enhance speed and reliability of transit service. Restrictions are only applicable during peak commuting periods.
8. **Los Angeles (Wilshire Blvd Transit Lanes)** – Example of transit priority lanes in a very large metropolitan area with high density development nearby. Bus-only restrictions are in place during peak hours and right-turning vehicles are permitted to use the lanes. Enforcement has been a challenge, with many motorists using the lanes for through movements at intersections. The lanes may be a pre-cursor to BRT along Wilshire Blvd.
9. **Omaha (ORBT)** – Example of emphasis on a single primary corridor, utilizing transit priority lanes in dense urban areas and TSP in low/moderate density suburban areas. Includes a potential contra-flow transit lane on a one-way street to streamline routing for patrons.
10. **Washington DC (Georgia Avenue)** – Example of short segments (small percentages of route alignment) utilizing bus priority lanes to enhance speed and reliability of transit service in a heavily-congested corridor within a large metropolitan area. Project is a pilot that may be extended based on performance and policy initiatives in the Georgia Avenue corridor.

RICHMOND

A Pulse bus picks up passengers at an elevated station, which allows more accessible at-level boarding. (Source: Greater Greater Washington.)

The GRTC Pulse opened in June 2018, with a 7.6-mile route with buses traveling in dedicated curbside lanes, an exclusive median busway, and general-use lanes. The route, which has an estimated travel time of 37 minutes, runs east and west through Richmond and serves an estimated 33,000 residents and 77,000 jobs within a half-mile of its path.[17,18]

The dedicated bus lanes run through downtown Richmond, providing stops at local universities (Virginia Commonwealth University - Monroe Campus and Virginia Union University) and a reinvigorated district with art, restaurants, and retail shops. The route is sponsored by two of the area's largest health systems, Bon Secours Richmond Health System and Virginia Common Wealth University Health System.[19] Since opening, the $64.9 million project has exceeded ridership projections, drawing an average 6,000 passengers daily.

BACKGROUND

The Pulse's east-west route through Richmond connects 14 stations. The technology along the route and on the specially-branded vehicles give buses priority at intersections (through transit signal prioritization) and the ability to move ahead of queuing vehicles (through queue jumps) at select intersections. These operational treatments make the run-time along the route faster and more reliable. All stations have a uniform design and feature real-time arrival information, a route-wide map spanning the back of the station, and traditional wayfinding signage. [20,21,22]

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[17] *GRTC Pulse Project Fact Sheet*. Greater Richmond Transit Company. Accessed Jan. 24. http://www.ridegrtc.com/media/main/14694.3_LANE_GRTC_FactSheet_Single_AltBlue.pdf

[18] *Prepare for the Pulse: Richmond's bus rapid transit system launches June 24*. Richmond Times-Dispatch. Accessed Jan. 24. https://www.richmond.com/news/local/city-of-richmond/prepare-for-the-pulse-richmond-s-bus-rapid-transit-system/article_b6d76b44-b8ba-5f9b-bd01-344f3127be22.html

[19] *GRTC Pulse*. Greater Richmond Transit Company. Accessed Jan. 24. http://ridegrtc.com/brt

[20] *GRTC Pulse Project Fact Sheet*. Greater Richmond Transit Company.

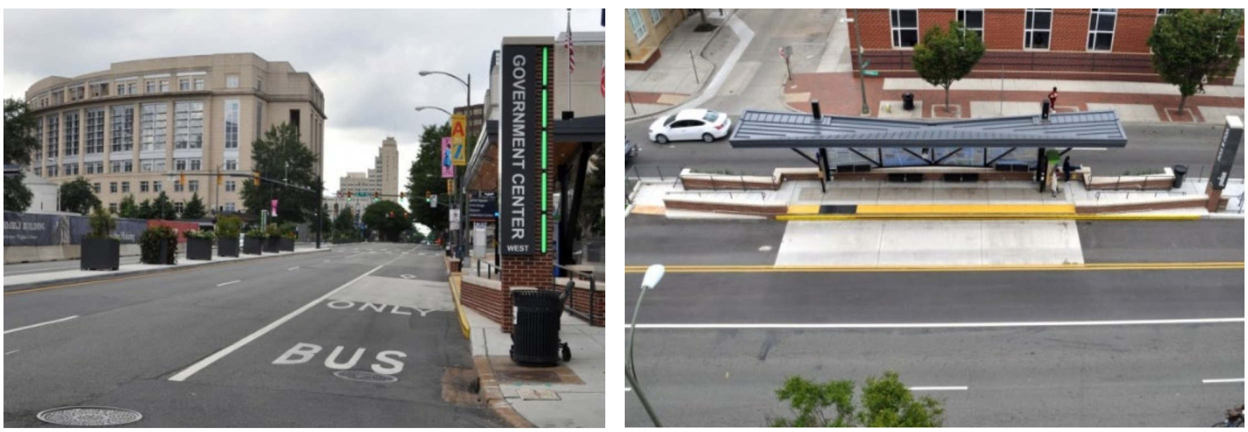
[21] *Prepare for the Pulse: Richmond's bus rapid transit system launches June 24*. Richmond Times-Dispatch.

[22] *Take a photo tour of Richmond's new Bus Rapid Transit*. Greater Greater Washington. Accessed Jan. 24. https://ggwash.org/view/69056/xx-photos-of-richmonds-new-brt

All stations are elevated to allow for level boarding (riders can board and alight the vehicle without steps or ramps), increasing accessibility for passengers and decreasing vehicle dwell time. Riders can prepay their fares with a mobile app or use machines at the stations that allow riders to pay with cash, credit, or tap cards distributed by the operator, a system that helps decrease dwell times due to fare collection.[23]

Approximately 3.2 miles of the route has dedicated bus lanes. The bus-only lanes have been implemented as curb-running lanes and a median busway in different sections of the route. Near the east and west ends of the route, vehicles operate in general use lanes with mixed traffic. The curbside bus-only lanes are reserved for buses at all times, seven days a week. Bikes are permitted in these bus lanes at all times as are cars making right turns as they approach the intersection. The median-running bus lanes are strictly bus-only. Bikes and turning vehicles are not permitted. To make left turns in areas with median-running lanes, motorists have their own left turn lanes and green arrow phase. Pulse buses must wait for these left turns to finish before they can proceed along the busway.

Starting at the easternmost station at the Rocketts Landing riverfront development, buses run in mixed traffic for two miles before reaching the Main Street station. Dedicated lanes begin in downtown as the route turns onto Broad Street, where the vehicles have exclusive use of the curbside lane. This area connects nine stations that provide access to the Convention Center, Government Center, and VCU Medical Center.[24] When the route reaches Foushee Street, the dedicated lanes shift lanes to the median, forming an exclusive busway for 2.5 miles, ending at Thompson Street.[25] West of Thompson Street, the buses return to mixed traffic until they reach the western terminus at the Willow Lawn Shopping Center.



The dedicated right-of-way used by The Pulse is located along the curb (left) or in a median busway (right). (Source: Greater Greater Washington)

In the median busway portions, eastbound and westbound stations are separated so that each is found on the "far side" of an intersection. This minimizes the space taken in the median for the stations and follows best practices for stop location to maximize the benefits of transit signal priority. Riders can enter and exit stations in the median busway via intersection crosswalks that connect to station ramps. The median-

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[23] *Take a photo tour of Richmond's new Bus Rapid Transit*. Greater Greater Washington.

[24] *Frequently Asked Questions*. Greater Richmond Transit Company. Accessed Jan. 24. http://ridegrtc.com/brt/frequently-asked-questions/

[25] Ibid

running busway minimizes conflicts with vehicles entering the road from side streets and entrances,[26] but it precludes opportunities for sharing the bus lanes with other modes, such as bicycles and turning vehicles.

The Pulse operates from 5:30 a.m. to 11:30 p.m. on weekdays and 6 a.m. to 11:30 p.m. on weekends. Buses run every 10 minutes from 7 to 9 a.m. and 4 to 6 p.m. and 15 minutes at other times. Fare costs area $1.50, (the same as for other local bus routes) and 75 cents for reduced-fare customers.

Bon Secours Richmond Health System and VCU Health System have agreed to pay $425,000 per year for five years for Pulse operating costs.[27] VCU is on the bus line in downtown and St. Mary's Hospital, which is owned by Bon Secours, is about a mile from the western end of the line.[28] The cost of constructing the system was $64.9 million, which included $7.6 million from the City of Richmond.[29]

Ridership and Reaction

Construction began in August 2016 after several years of planning. Studies in the early 2000s pointed to the need for rapid transit, with a Broad Street Rapid Transit Study dating to 2009.[30] Supporters considered approving the plan the first step toward creating a regional transit system. Opponents of the project argued that, among other concerns, the service did not extend to communities that were not served by transit at the time.[31]

Ridership has outpaced expectations. The service had a projected average daily ridership of 3,500, but that figure had reached 6,000 daily as of September 2018. Sunday ridership was projected to be about 1,600 but has reached 2,000 to 3,000. In its first week, during which GRTC offered free fares, it drew 56,952 riders. Last summer, the bus operator reported that ridership had steadily increased with revenue-generating service to about 30,000 to 36,000 per week.[32] Ridership has been aided through partnerships with Virginia Commonwealth University and Richmond Public Schools that allow students and faculty to ride free.[33]

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[26] *Frequently Asked Questions*. Greater Richmond Transit Company.

[27] *Prepare for the Pulse: Richmond's bus rapid transit system launches June 24*. Richmond Times-Dispatch.

[28] *GRTC announces $6.4 million sponsorship of Pulse bus line by VCU Health, Bon Secours*. Richmond Times-Dispatch. Accessed Jan. 24. https://www.richmond.com/news/local/city-of-richmond/grtc-announces-million-sponsorship-of-pulse-bus-line-by-vcu/article_e300b40e-d37b-5741-b4b0-1796e085336b.html

[29] *Frequently Asked Questions*. Greater Richmond Transit Company.

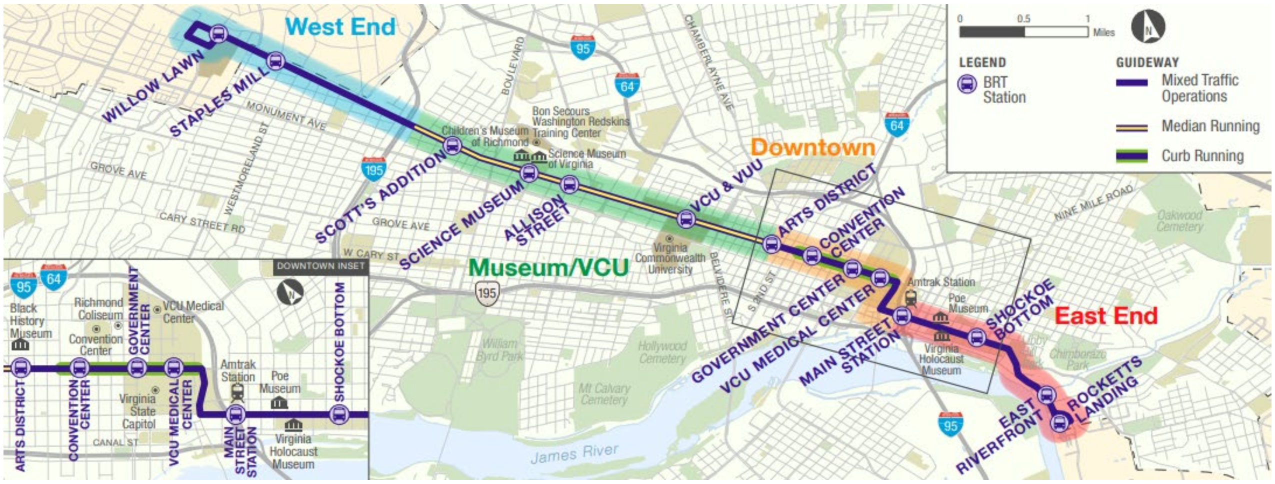
[30] *Broad Street Rapid Transit Study Project Overview and History*. Greater Richmond Transit Company. Accessed Jan. 24 http://ridegrtc.com/media/main/brt/Broad%20Street%20Rapid%20Transit%20Study%20Overview%20and%20History.pdf

[31] *After heated debate, Council approves $49 million bus rapid transit project*. Richmond Times-Dispatch. Accessed Jan. 24. https://www.richmond.com/news/local/city-of-richmond/after-heated-debate-council-approves-million-bus-rapid-transit-project/article_7833e688-670d-5c5c-b6d1-a63818d0ff9d.html

[32] *GRTC Pulse Ridership Continues to Exceed Expectations Three Months In*. Greater Richmond Transit Company. Accessed Jan. 24. http://ridegrtc.com/news-initiatives/press-releases/grtc-pulse-ridership-continues-to-exceed-expectations-three-months-in/

[33] *Despite outperforming ridership goals, GRTC is $1 million below budgeted revenue*. Richmond Times-Dispatch. Accessed Jan. 24. https://www.richmond.com/news/local/city-of-richmond/despite-outperforming-ridership-goals-grtc-is-million-below-budgeted-revenue/article_16a49998-2dd3-5f1d-b3a4-7ae451e7a34a.html

Despite the high ridership, service is nearly $1 million below budgeted revenue, with some pointing to lax fare enforcement as a problem.[34]



GRTC Pulse route and stations. (Source: Greater Richmond Transit Company)

[34] *Despite outperforming ridership goals, GRTC is $1 million below budgeted revenue*. Richmond Times-Dispatch.

RICHMOND PULSE CASE STUDY		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	11,900 (2015) to increase to 14,400 in 2035
	Transit Mode Share	
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	10 to 15 minutes mornings; 30 minutes late evening and early mornings
	Transit Signal Priority	Yes
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	On-street parking along Broad Street is underutilized with occupancies between 30% and 60% for all time periods studied. 306 parking spaces reduced due to BRT
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	3 lanes in each direction
	Lane Width	10' x 2 directions median running Bus priority lanes. (West of Downtown) 10' x 2 directions curb running Bus priority lanes. (downtown) Mixed traffic (east of Downtown)
	Intersection Design	Separate signals for Buses.
	Separation of traffic	Before - 6 lanes mixed traffic After - 4 lanes mixed traffic + 2 bus lanes (without red paint), bikes allowed in transit lanes
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	\$49.8 million (\$24.9 million TIGER grant)+(\$16.9 million – Virginia DRPT)+(\$7.6 million – City of Richmond)+(\$400,000 – Henrico County)
	Project Length	7.6 miles with 14 stops

ORLANDO

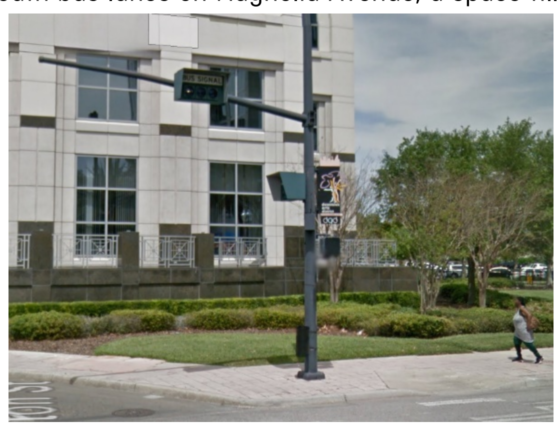
LYMMO opened in 1997 in downtown Orlando as a branded downtown circulator route supported by transit priority lanes. It is considered one of the nation's first bus-rapid transit systems.[35] When introduced, it was the latest in a succession of circulators that provided transit from parking garages on the periphery of downtown to work and entertainment destinations in the central business district. The service has remained free since opening with funding provided by Orlando's Downtown Development Board and Parking Division.[36]

BACKGROUND

LYMMO began with a single three-mile loop, now called the Orange Line, connecting the Centroplex Garage to Orlando City Hall. Today, LYMMO has since expanded to include four downtown lines, with the additional routes utilizing the dedicated right-of-way for part of the trip and running in mixed traffic elsewhere. The bus frequencies range from a minimum of five minutes during business hours and 20 minutes at other times.[37] Two routes, the Orange and Grapefruit lines, provide connections to SunRail, Central Florida's commuter rail system.

LYNX describes the LYMMO service as "rail like," pointing to the dedicated bus-only lanes.[38] Magnolia Avenue, which the north-south dedicated lanes run along, received special design focus during the creation of the service, with the aim of integrating streetscaping, landscaping, and bus facilities.

The two-way dedicated lanes are delineated from traffic with solid, white lines and raised reflectors for most of the route. A raised median separates the north and south bus lanes on Magnolia Avenue, a space filled with at-grade landscaping, planter columns, and custom-designed light poles. The medians widen at stations to accommodate covered bus shelters for northbound passengers. A special paint scheme, paving, and hardscape helps to further distinguish the dedicated bus lanes from adjacent general-use lanes.[39]



A bus-only signal shown above controls LYMMO vehicles in downtown Orlando. (Source: Google Street View)

Intelligent Transportation System elements along the route include a sensor embedded in the street that tracks vehicle locations, allowing buses to preempt traffic signals and receive crossing priority (a form of transit signal priority). The technology also updates the location of buses on kiosk maps and triggers audio and blinking pavement lights to alert riders to the

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[35] *LYMMO History/Timeline*. LYNX. Accessed Jan. 21. https://www.golynx.com/plan-trip/riding-lynx/lymmo/lymmo-history.stml

[36] Ibid

[37] *LYMMO Downtown Circulator*. City of Orlando. Accessed Jan. 21. https://beta.orlando.gov/Parking-Transportation/Public-Transit/LYMMO

[38] *LYMMO*. LYNX. Accessed Jan. 21. https://www.golynx.com/plan-trip/riding-lynx/lymmo/

[39] *LYMMO Bus Rapid Transit Downtown Circulator*. Nashville Area Metropolitan Planning Organization, North East Corridor Mobility Study. Accessed Jan. 21. http://www.nashvillempo.org/northeast/LYNX%20LYMMO%20Background.pdf

bus's arrival.[40] At intersections, bus movements are controlled with separate signals to avoid confusion with those for general traffic.

The creation of LYMMO was the culmination of various efforts to provide low-cost or free circulator service in Downtown Orlando as part of broader redevelopment goals for the area. Previous iterations of the circulator included the Meter Eater, which cost 25 cents per ride, and the FreeBee, the City offered fare-free through parking revenues. The City and LYNX also explored developing a street car system, the cost of which led them to pursue a bus-based option and, eventually, the creation of LYMMO.[41] The system cost $21 million to create, with $5.25 million of local funds.[42] The service has been free since its creation, the downtown development board's executive director recently suggested the fare-free service may be revaluated.[43]

Station kiosks, like the one highlighted above, provide LYMMO passengers with real-time arrival information at covered stations. (Source: Google Street View)

ROW in one section of the route includes separate LYMMO lanes and, next to general traffic, dedicated bike lanes in both directions. (Source: Google Street View)

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[40] *LYMMO Bus Rapid Transit Downtown Circulator*. Nashville Area Metropolitan Planning Organization.

[41] *LYMMO BRT: 15 Years Later*. Federal Transit Administration. Accessed Jan. 21. https://www.transit.dot.gov/sites/fta.dot.gov/files/FTA_Report_No._0042.pdf

[42] *Lynx LYMMO Bus Rapid Transit Evaluation*. Federal Transit Administration. Accessed Jan. 21. https://nbrti.org/wp-content/uploads/2017/05/lymmo-7-03.pdf

[43] *Lynx to make adjustments to downtown Lymmo, other routes in 2019*. Orlando Business Journal. Accessed Jan. 21. https://www.bizjournals.com/orlando/news/2018/12/12/lynx-to-make-adjustments-to-downtown-lymmo-other.html

Ridership and Reaction

A 2001 survey found passengers rode LYMMO for purposes one would expect – short trips to work and to run errands around downtown.[44] Many were on board for one to two stops before alighting, with trip times only a few minutes in length. The survey found that, at the time, about 40 percent used the service two or three times a day and more than half of riders did not use any another transit service offered by LYNX. However, more than half of the respondents said LYMMO had improved their overall opinion of public transit.

A survey completed in 2012 found changes in trip purposes among passengers, fewer of whom used the service to reach work. More passengers were using it to reach lunch spots and run errands. More than half of respondents reported using the service more than twice a day. Passengers who reported using it four times a day increased from 13 to 21 percent since 2001. Seventy-six percent of respondents thought LYMMO had reduced congestion in downtown and about 80 percent thought LYMMO had made Orlando a more attractive place to live and work.[45]

Average weekday ridership when the service opened in 1997 was 3,091, which exceeded expectations. Ridership leveled off in 1998 and then began to drop in 2010. Average ridership in 2012 was 3,017. The fluctuation in ridership has been attributed, in part, to a drop in the total number of jobs within a quarter mile of the LYMMO route.[46]

A 2003 evaluation found the average weekday speed of the LYMMO was 9 mph, compared to an average speed of 9.9 mph for its predecessor, FreeBee, which operated without the benefit of many of the features of the current service. The evaluation found that LYMMO would likely run much slower without the features, however, because it had more stops and higher ridership, which increased station dwell time compared to FreeBee. LYMMO also stops at each station regardless of whether a passenger has requested a stop.[47]

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[44] *Lynx LYMMO Bus Rapid Transit Evaluation*. Federal Transit Administration.

[45] *LYMMO BRT: 15 Years Later*. Federal Transit Administration.

[46] Ibid

[47] *Lynx LYMMO Bus Rapid Transit Evaluation*. Federal Transit Administration.

LYMMO's current service map. The dedicated lanes are located primarily along the Orange Line along Magnolia Avenue. [Source: LYNX]

ORLANDO LYMMO CASE STUDY		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	4 routes (60-63) daily Ridership = 2,530 (FY18)
	Transit Mode Share	97% Private transport, 2% public transport
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	Ranging from 5-7 min to 20 mins 185 trips (loops) Monday–Thursday, 200 trips Friday, 85 trips Saturday, and 65 trips Sunday
	Transit Signal Priority	LYMMO includes Intelligent Transportation Systems elements: transponders to track bus locations and timepoints, kiosks at stations, and signal priority.
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	Commercial and Office spaces
	Context Classification/ Complete Streets	
	Parking/Curb space	Parking not allowed
	Accessibility	35,807 jobs within ¼ mile in 2010
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	3 lanes. One Way for mixed traffic. One or Two ways for bus depending on the locaiton
	Lane Width	12' Dedicated lane with physical barrier (one way) 10'6" Dedicated lanes with physical barrier between Bus lanes in two directions and between bus lane and mixed traffic
	Intersection Design	Separate logo for signs at stops
	Separation of traffic	Separate lane including extensive signage and pavement painting
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	$21 million (50% federal, 25% state, 25% local) 1996 Funded by the City of Orlando's Downtown Development Board and Parking Division. Annual Operating cost $ 2.25 Million (FY-18)
	Project Length	3 miles (downtown only)

BALTIMORE

Baltimore introduced dedicated bus lanes in May 2017 as part of a broader overhaul of the city's transit service. The Maryland Transit Administration (MTA) added the lanes on high-frequency bus routes where the newly dedicated right-of-way could carry the same number of people as an adjacent general-use lane.[48]

Baltimore bus-only lanes created dedicated right-of-way for transit along curbs and adjacent to street parking (Source: Baltimore Sun)

The 5.5 miles of dedicated right-of-way includes lanes that run along curbs and adjacent to on-street parking. One section converts to bus-only during peak evening travel times only. Despite issues with prohibited vehicles occasionally blocking the bus lanes, MTA points to improved travel times for transit riders on routes using the lanes and a decline in bus-related accidents systemwide as evidence of their success.

BACKGROUND

Baltimore has long had bus-only lanes on two downtown thoroughfares, Lombard and Pratt Streets. These dedicated lanes were created in 2009 but often went unenforced and ignored by most drivers. As part of the region's transit system reorganization, branded BaltimoreLink, a red surface treatment was added to these lanes to distinguish them from general-use lanes, aiding in enforcement and compliance. At the same time, dedicated bus lanes were implemented on six other streets using the same red surface treatment.[49,50]

The overhaul created a total of nine bus-only lanes in downtown. Most of the lanes run curbside or adjacent to parking, except for a portion of Charles Street, where a parking and right-turn lane converts to bus-only from 4 to 6 p.m. on weekdays. The lane is unpainted but marked with street markings and signs.[51]

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[48] *New Dedicated Baltimore Link Bus Lanes Coming to Downtown Baltimore Starting Week of May 15, 2017*. Baltimore City Department of Transportation. Accessed Jan. 25. https://www.baltimoresun.com/business/bs-md-mta-bus-cameras-20180301-story.html

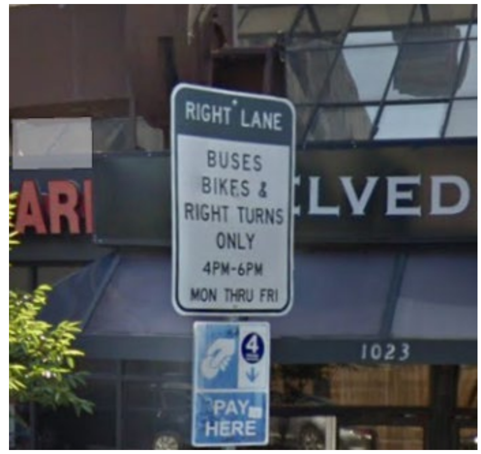
[49] *It's No Red Line, But These New Transit Lanes Will Speed Up Trips for Baltimore Bus Riders*. Streets Blog USA. Accessed Jan. 25. https://usa.streetsblog.org/2017/05/16/its-no-red-line-but-these-new-transit-lanes-will-speed-up-trips-for-baltimore-bus-riders/

[50] *Drivers warned to stay out of Baltimore's new bus lanes*. WBAL-TV. Accessed Jan. 25. https://www.wbaltv.com/article/drivers-warned-to-stay-out-of-baltimore-s-new-bus-lanes/7148528

[51] *Dedicated Bus Lanes Workshop*. Maryland Department of Transportation. Accessed Jan. 25. https://mta.maryland.gov/baltimorelink/images/library/dedicated_lanes/dedicated_bus_lanes_boards_web_2016.pdf

The more than five miles of red lanes cost MTA approximately $5 million to paint, which was part of the $135 million system reorganization.[52] Besides decreasing transit travel times, MTA described the goals of implementing the lanes as improving safety, making transit a more attractive transportation option, and supporting the vibrancy of downtown.

To select streets for the project, MTA evaluated 25 downtown streets with frequent local bus service. The potential streets were narrowed to those with high-frequency service, defined as more than 18 buses per hour. The streets were further narrowed by identifying those where the number of potential passengers that would be carried in a bus-only lane would be more than those in an adjacent general-use lane. For example, MTA noted that the Lombard Street bus lane could move 1,000 riders per hour compared to 700 people in an adjacent car lane.[53]



A sign notifies drivers that the right lane of Charles Street converts to bus-only at peak travel times. (Source: Google Street View)

Bicycles, emergency vehicles, and cars maneuvering into parallel parking spaces along the route can use the lanes. While all other vehicles are prohibited, including taxis, ridesharing vehicles, and loading vehicles, drivers may enter them to make right turns about a half block before reaching an intersection. Areas where turning vehicles can mix with buses are marked with dashed red paint.[54]

The dedicated bus lanes and BaltimoreLink project were initiated after plans for the Red Line light rail project ended. BaltimoreLink, announced in 2015, also included the introduction of signal prioritization technology for transit vehicles on certain routes, with some overlap between TSP and dedicated lanes improvements.[55]

Ridership and Reaction

In the month after the implementation of BaltimoreLink, ridership systemwide fell approximately 23 percent, but the system has since rebounded. In May 2018, riders took 5.9 million trips. That month, average weekday trips stood at 226,102, with 125,332 trips per Saturday, and 81,817 per Sunday or holiday.[56] While ridership numbers specific to the dedicated bus lanes is not readily available, MTA has said the newly-painted lanes

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[52] *New Dedicated BaltimoreLink Bus Lanes Coming to Downtown Baltimore Starting Week of May 15, 2017*. Baltimore City Department of Transportation.

[53] *It's No Red Line, But These Transit Lanes Will Speed Up Trips for Baltimore Bus Riders*. Streets Blog USA

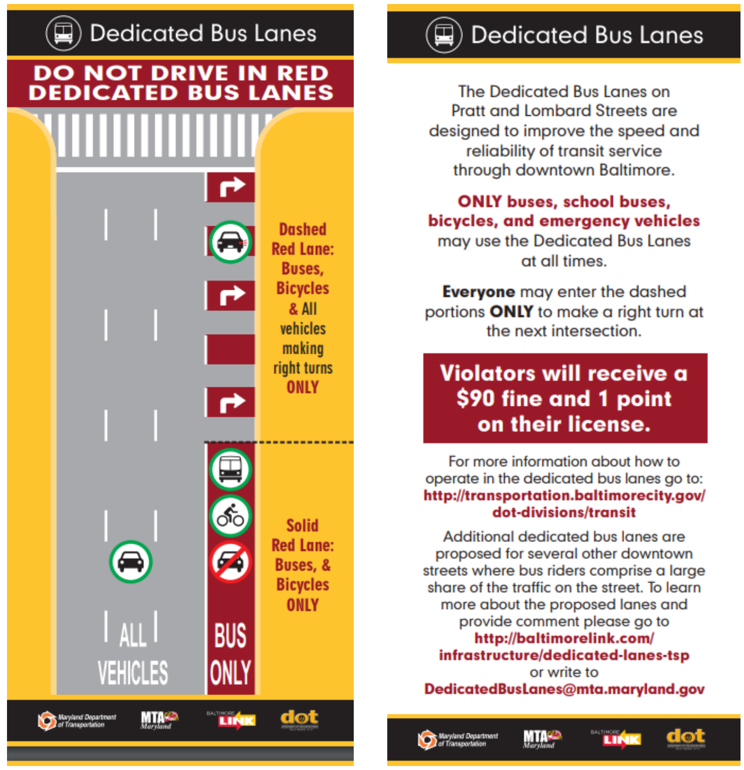
[54] *Dedicated Bus Lanes Workshop*. Maryland Department of Transportation.

[55] *It's No Red Line, But These Transit Lanes Will Speed Up Trips for Baltimore Bus Riders*.

[56] *One year of BaltimoreLink bus system: Ridership bounces back, reliability still falls short*. Baltimore Sun. Accessed Jan. 25. http://www.baltimoresun.com/news/maryland/baltimore-city/bs-md-baltimorelink-one-year-20180608-story.html

on Pratt and Lombard Streets have reduced bus travel times up to 25 percent.[57] After the broader system changes, bus accidents dropped 20 percent and bus-related complaints dropped 49 percent.[58]

Enforcing the bus-only lanes has been an issue. A year after their introduction, riders complained about cars and trucks blocking the bus lanes, forcing buses to wait and/or re-enter adjacent mixed-traffic lanes.[59] In the first half of 2018, MTA police issued 277 citations and 149 warnings for bus lane violations. In the same time period, they also handed out 881 tickets for parking in bus lanes or blocking bus stops. An average 600 citations for parking in bus lanes or at bus stops are issued per month.[60] The violations prompted lawmakers to propose enforcement using cameras.[61] Drivers can face a $90 fine and a point on their license for parking or driving in the dedicated bus lanes.[62]



A notice distributed by transit agencies warning drivers not to block bus-only lanes. (Source: BaltimoreLink.com)

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[57] *Tired of scofflaws, bus riders call on city and MTA for better bus lane enforcement*. Baltimore Fishbowl. Accessed Jan. 25. https://baltimorefishbowl.com/stories/tired-of-scofflaws-bus-riders-call-on-city-and-mta-for-better-bus-lane-enforcement/

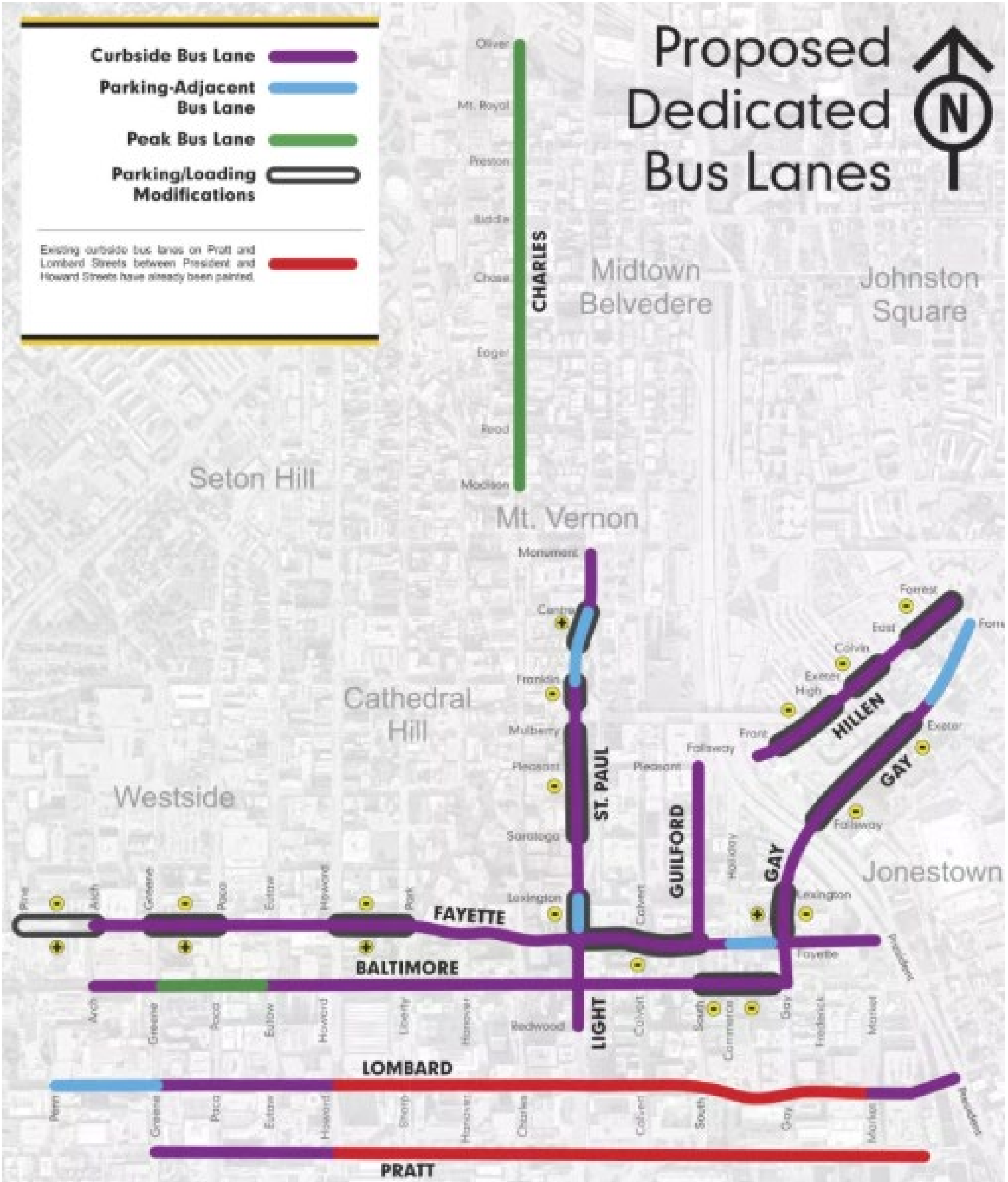
[58] *One year of BaltimoreLink bus system: Ridership bounces back, reliability still falls short*. Baltimore Sun.

[59] Ibid

[60] Ibid

[61] *Bill proposes surveillance cameras to keep motorists out of Baltimore's bus-only lanes*. Baltimore Sun. Accessed Jan. 25. https://www.baltimoresun.com/business/bs-md-mta-bus-cameras-20180301-story.html

[62] *Drivers warned to stay out of Baltimore's new bus lanes*. WBAL-TV.



A map of bus-only lanes in downtown Baltimore (Source: Streets Blog USA)

BALTIMORE BUS LANES CASE STUDY		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	> 1,000 per hour
	Transit Mode Share	
	Traffic Volume	34,500 AADT (2016) on W Lombard St 5,300 AADT (2016) on W Baltimore St
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	More than 18 buses per hour (multiple routes)
	Transit Signal Priority	Yes
	Person/Vehicle Delay	
	Average Travel Speeds	<9 mph Before
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	Downtown (No planned land use changes)
	Context Classification/ Complete Streets	
	Parking/Curb space	Parking and loading locations changes vary along the corridor.
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	3 types of Bus lanes Curbside, Parking-Adjacent, Peak-Only,
	Lane Width	
	Intersection Design	
	Separation of traffic	Shared by MTA buses, Charm City Circulator, other buses/shuttles, right-turning vehicles (for ½ block in advance of turn), emergency vehicles, bicycles, cars while parallel parking in adjacent on-street parking
Other	Safety	MTA reports a decline in bus-related accidents resulting from the dedicated bus lanes
	Enforcement	MTA Police can issue moving violations wherever MTA provides service.
	Maintenance	
	Cost	
	Project Length	By the end of 2017 nearly 5.5 lane miles of dedicated bus lanes were in place, with 4.9 mi of full-time lanes with red paint (methyl methacrylate) and appropriate signing and markings, and 0.5 mi of peak-only lanes with signage and pavement markings but no paint.

Albuquerque

Albuquerque's Bus Rapid Transit, also known as ART, is a BRT line planned to serve 13.5 miles of Central Avenue, the main east-west thoroughfare of the city. Construction of BRT treatments, included dedicated running way, was completed in November 2017. However, full implementation has been stalled while the city resolves operational issues.

Buses are scheduled to arrive every 7 to 8 minutes between 6:30 a.m. and 6:30 p.m. and every 15 minutes at other times. The service will run on segregated, exclusive, median bus lanes throughout the corridor, except in one-way sections in downtown, where they will run on the leftmost lane.

This is the only line in the country to have a BRT Gold standard certification, as it has all the features of a full-fledged BRT: dedicated, BRT-only bus lanes; level boarding stations every half a mile in the dense areas; off-board ticketing; and transit signal priority. It also includes features like High-intensity Activated Crosswalk beacons (HAWK) which allows pedestrians to access the stations safely. The projected daily ridership for ART is 15,750.

The rollout of ART has been delayed due to several problems with the electric vehicles the service was supposed to utilize. As recently as fall 2017, Albuquerque's mayor announced the city was returning 15 of the ART vehicles to their manufacturer because they turned out to have a shorter than expected battery life, limiting the number of miles they could travel. The vehicles ran about 175 miles between charges, 100 fewer miles than promised. The city is now planning to operate ART with diesel- or gas-power vehicles instead.[63]

An example of an electric bus like the models initially planned for ART. The city is now planning to use gas or diesel buses due to problems with battery life. (Source: City of Albuquerque)

[63] *Albuquerque's Groundbreaking Bus Project Stalled.* Streets Blog USA. Accessed Feb. 17. https://usa.streetsblog.org/2018/11/21/albuquerques-groundbreaking-bus-project-stalled/

ALBUQUERQUE (ART) CENTRAL AVENUE CASE STUDY		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	15,750 (projected) 12,075 (2017) on the corridor including the slow version of the bus 14,000 based on the consultant's website
	Transit Mode Share	8.8 miles exclusive BRT out of total of 17 miles
	Traffic Volume	ADT 18,000 to 38,000 on Central Avenue Corridor 2017
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	Albuquerque Rapid Transit promises to improve travel time by 15% and on-time performance by 20-25%.
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	Peak 7 min Off-Peak 15 min
	Transit Signal Priority	Yes
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	Mostly commercial on Central Ave
	Context Classification/ Complete Streets	
	Parking/Curb space	18 parking spaces added throughout the corridor
	Accessibility	Line connects 32 of 37 bus routes
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	2 bus lanes + 2 mixed traffic lanes + 2 parking lanes + sidewalks
	Lane Width	12' BRT lanes in segregated sections
	Intersection Design	
	Separation of traffic	Previously: Non-segregated rapid bus in mixed traffic Final: 8 miles of segregated median running BRT
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	$119 million ($ 100 million federal funding)
	Project Length	9 miles

CLEVELAND

HealthLine is a 7.1-mile BRT corridor connecting Cleveland's largest regional employment areas. It runs along Euclid Avenue, connecting University Circle to downtown and extending east to the Louis Stoke Station at Windermere. The buses operate in dedicated median lanes beginning at E. 105th Street in the University Circle area and west to downtown.

Source: National Association of City Transportation Officials

Since opening in October 2008, HealthLine has served more than 44 million customers. Its annual ridership has increased about 60 percent compared to the Number 6 bus line, the previous service. The Number 6 route was RTA's highest ridership bus line before it was replaced by HealthLine. More than $9.5 million in economic development along Euclid Avenue has been attributed to the HealthLine. [64]

The route takes an average of 44 minutes to travel, about three minutes faster than the line it replaced, according to a 2010 news report based on data provided Greater Cleveland Regional Transit Authority (RTA).[65] Though HealthLine was initially designed with signal priority to allow buses to move ahead of traffic at intersections, it's unclear to what extent the system is currently used. A member of RTA's Citizen Advisory Board stated that the city turned off the signal priority soon after HealthLine launched due to complaints about delay.[66]

HealthLine's fare enforcement practices have faced scrutiny since the route's launch, with changes impacting wait times for riders. The service initially allowed riders to pay their fare before boarding and enter through any door, which decreased station dwell time. To enforce fare payment, police officers would stop buses at random to check fare cards. The practice was ruled unconstitutional in 2017 by a Cleveland municipal judge.[67] After the ruling, police officers began checking fares as riders boarded vehicles.[68]

[64] *RTA's HealthLine -- the world-class standard for BRT service*. Greater Cleveland Regional Transit Authority. Accessed Feb. 8, 2019. http://www.riderta.com/healthline/about

[65] ibid., and *HealthLine Buses Moving Slower Than Expected on Euclid Avenue*. Cleveland Plain Dealer. Accessed Feb. 18, 2019. http://blog.cleveland.com/metro/2010/07/healthline_buses_moving_slower.html

[66] *The Ridiculous Politics that Slow Down America's Best BRT Route*. Streets Blog USA. Accessed Feb. 18, 2019. https://usa.streetsblog.org/2014/06/12/the-ridiculous-politics-that-slow-down-americas-best-brt-route/

[67] *Cleveland Police Enforcement of Transit "Proof-of-Payment" Ruled Unconstitutional*. Streets Blog USA. Accessed Feb. 18, 2019. https://usa.streetsblog.org/2017/11/02/cleveland-police-enforcement-of-transit-proof-of-payment-ruled-unconstitutional/

[68] *Riders fault HealthLine's new method of checking tickets*. Cleveland Plain Dealer. Accessed Feb. 18, 2019. https://www.cleveland.com/metro/index.ssf/2017/11/riders_fault_healthlines_new_method_of_checking_tickets_photos.html

CLEVELAND HEALTH LINE CASE STUDY		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	60% above former Route 6, which it replaced
	Transit Mode Share	
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	3 minutes faster running time than former Route 6 (44 minutes observed time)
	Transit Service Frequency	10 minutes on-peak, 10-15 minutes off-peak
	Transit Signal Priority	In place but deactivated due to concern over motorist delays at intersections.
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	Eastern terminus near Case Western Reserve University and Cleveland Medical Center; Western terminus in Downtown Cleveland. Line has spurred substantial (re)development along Euclid Ave.
	Context Classification/ Complete Streets	
	Parking/Curb space	
	Accessibility	Median station access via crosswalks
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	Single lane for auto traffic in each direction.
	Lane Width	
	Intersection Design	Median running lanes requires separate signal phases for buses and left-turning vehicles
	Separation of traffic	Exclusive median running bus lane; separate bike lanes on right shoulder
Other	Safety	
	Enforcement	Fare enforcement by police as riders board.
	Maintenance	
	Cost	
	Project Length	7.1 miles

EUGENE (OR)

Source: Metro Magazine

The Emerald Express, or EmX, is a Bus Rapid Transit system serving the cities of Eugene and Springfield in Oregon. Lane Transit District, the public transit authority of Lane County, operates the system.

EmX comprised of three sections/lines named Green, Gateway, and West Eugene that cover 28 miles:

- The Green line began service in January 2007. The line replaced route 11 that previously ran along the corridor. Buses run at a frequency of 10 to 20 minutes on weekdays between 6 am and 11 pm. Rush hour travel time was reduced from 22 minutes to 16 minutes on the Green line corridor.
- The Gateway corridor started operation in January 2011, connecting EmX to Gateway mall.
- The West Eugene corridor, the latest piece, began operation in September 2017.

All the BRT vehicles are given transit signal priority though a ground loop signaling the traffic control system. Buses run on dedicated corridors on the median for about 60 percent of the route and in mixed traffic for the remaining 40 percent.

The dedicated, physically separated bus lanes in this project, for the most part, are not paved for their entire width. They are paved where the tires touch the surface and the gaps are landscaped with turf. This treatment may make it difficult or impossible for other vehicles (emergency vehicles, e.g.) to use the restricted lanes. In sections where the segregated lanes are not physically separated from mixed traffic, the buses still run in the left lane, and stations are located in the median. The dedicated lanes are marked and labeled as bus-only. None of the dedicated bus lanes are painted red, but their distinctive design likely provides an enforcement benefit similar to that associated with red surface treatments. On some one-way streets, the bus lane is in a center exclusive lane, allowing right-turning vehicles to utilize the curbside lane.

Source: The Transport Politic

EUGENE (OR) EMERALD EXPRESS CASE STUDY		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	6,000 average (weekday)
	Transit Mode Share	Existing - 87% Auto, 4% Transit, 9% Bike/walk
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	10 to 15 minutes weekdays; 15 to 30 minutes evenings and weekends
	Transit Signal Priority	Yes
	Person/Vehicle Delay	
	Average Travel Speeds	Operating speed - 17 mph
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	This corridor includes a contiguous MUP all along its path. Sidewalks and bike lanes in the downtown section + 2 x 2 lane roadway on either side.
	Parking/Curb space	
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	6 lanes in the two-way section 1 -2 lanes in the one-way section
	Lane Width	12'6" at curbside sections 2 x 11' at median running sections
	Intersection Design	Separate signals for buses at all signalized intersections
	Separation of traffic	6 miles of segregated lanes (bus only) + 3 lanes of mixed traffic
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	Side Lane BRT (BRT Elements and related improvements) - $170 Million Annual M&O = $49,500,000
	Project Length	6 miles of segregated lanes (Curbside & Median) + 3 miles of mixed traffic

Jacksonville

The South East Corridor BRT is operated as Route 107 (Blue line) by Jacksonville Transportation Authority. The line opened in 2016, one year after its non-BRT express bus route 102 (or the Green line). The Blue line is a 11.1-mile long route with 1.5 miles of bus priority lanes along the downtown portion of the corridor and along certain sections of Kings Ave. Buses run at a frequency of 10 to 15 minutes. In order to reduce dwell time at stops, off-board ticket vending machines have been installed at all stops.

Four one-way streets in downtown Jacksonville have their right lane designated as a bus priority lane. The lanes are marked by a solid white line rather than a red surface treatment. Cars are not allowed in bus lanes during peak hours (6 a.m. to 9 a.m. and 3 p.m. to 6 p.m. on weekdays). In select locations, the bus lane may be used by cars for right turns. Emergency vehicles, bicycles, and school buses can use the bus lanes at any time. A queue jump for buses is located at the intersection of W. Forsyth Street and N. Jefferson Street. Buses have transit signal priority at all intersections.

The Kings Avenue bus lanes are denoted by a solid white line. Cars making right turns are allowed to use the bus lanes at some intersections. Restrictions apply only during peak commuting hours. (Source: Google Street View)

JACKSONVILLE (FL) SOUTHEAST CORRIDOR CASE STUDY		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	8,900 (split between the BRT only sections of 4 different routes)
	Transit Mode Share	
	Traffic Volume	AM peak 2012: between 200 and 2,907 throughout the corridor (mostly above 1,000)
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	10 - 15 mins
	Transit Signal Priority	Yes + Queue Jump Lanes
	Person/Vehicle Delay	
	Average Travel Speeds	24 - 28 mph
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	
	Accessibility	Minority population - 66.42% Low income population = 14.42% Pop over 64 = 9% (study area)
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	
	Intersection Design	
	Separation of traffic	re-designation of existing pavement currently striped for parking as bus-only lanes
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	
	Project Length	11.1 miles 8 stops

Los Angeles

With 93,000 weekday bus boardings, Wilshire Boulevard is a critical transit corridor in Los Angeles County. A section of it was selected to be implemented as peak hour transit priority lanes to improve bus travel time reliability, a 3.5-mile alignment in operation since July 2013.

Only buses and bicyclists can use the dedicated lanes during peak weekday travel times of 7 am to 9 am and 4 pm to 7 pm. The Wilshire BRT Project cost $31.5 million, with a federal share of $23.3 million and the city of Los Angeles and the Los Angeles County Metropolitan Transportation Authority contributing a $8.2 million local match.[69,70]

Source: Los Angeles Magazine

At certain intersections, general traffic can use the bus-only lanes to make right turns during peak travel times (7 am to 9 am and 4 pm to 7 pm). According to news reports, many drivers use the bus-only lanes to proceed forward through an intersection rather than make a right turn, creating conditions that block transit vehicles.[71]

The Los Angeles County Metropolitan Transportation Authority places enforcement of the exclusive bus lanes among its priorities in its strategic plan. Its aim is to achieve a minimum average speed of 18 mph on rapid bus routes. The operator will also study converting service like that provided on Wilshire Boulevard to bus-rapid transit. [72]

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[69] *Wilshire Bus Rapid Transit (BRT) Initial Study/Environmental Assessment*. Los Angeles County Metropolitan Transportation Authority. Accessed Feb. 8. http://media.metro.net/projects_studies/wilshire/images/Fact%20Sheet%202.pdf

[70] *Wilshire BRT Dedicated Bus Lane Opened, June 5, 2013*. Los Angeles County Metropolitan Transportation Authority. Accessed Feb. 8. https://www.metro.net/projects/bus-rapid-transit-studies/dedicated-bus-lane/

[71] *Law-Breaking Drivers Disrespecting New Wilshire Boulevard Bus-Only Lanes*. Streets Blog USA. Accessed Feb. 18. https://la.streetsblog.org/2015/05/19/law-breaking-drivers-disrespecting-new-wilshire-boulevard-bus-only-lanes/

[72] *Metro Strategic Plan*. Los Angeles County Metropolitan Transportation Authority. Accessed Feb. 18. http://libraryarchives.metro.net/DB_Attachments/Report_Metro%20Strategic%20Plan_DRAFT%20v5_2018-4-2.pdf

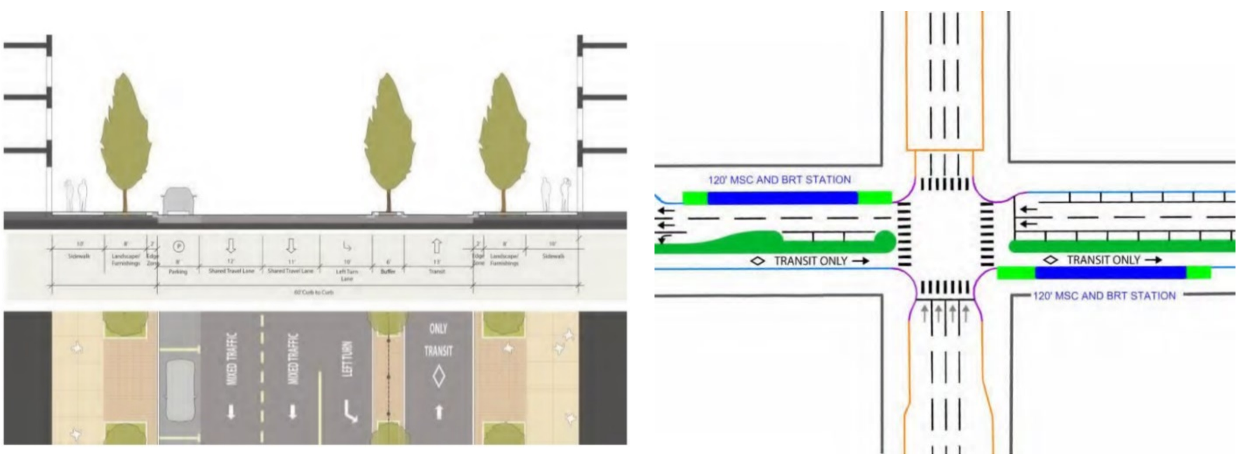
LOS ANGELES WILSHIRE BOULEVARD CASE STUDY		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	13,000 per weekday (route 20) 27,340 per weekday (route 720 express)
	Transit Mode Share	
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	3 minutes (peak) to 10 mins (off peak)
	Transit Signal Priority	Yes
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	11 parking spaces removed
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	
	Intersection Design	
	Separation of traffic	Right lane reserved for buses on weekday peak hours. Solid white line with slight difference in shade than the adjacent pavement to demarcate bus only lanes.
	Access management	Buses and Bikes are allowed. Right turning cars are allowed at intersections
Other	Safety	
	Enforcement	Violations by motorists have been noted, especially at intersections (through movements instead of right turns)
	Maintenance	
	Cost	$31.5 million ($23.3 million federal share)
	Project Length	3.5 miles

Omaha

ORBT, or Omaha Rapid Bus Transit, is an 8.5-mile bus priority corridor utilizing the Dodge Street (US 6) and Farnam Street corridors. Planning for ORBT is being led by Metro, the city's public transport authority. The line intersects most other bus lines of Omaha, providing a rapid-transit axis with high connectivity to local fixed-route services. The ORBT alignment is planned to include Business Access and Transit (BAT) lanes east of 30th Street and a transit signal priority (TSP) corridor in a less dense area west of 30th Street. ORBT route is expected to operate at 10-minute headways and adopt stop spacing standards that minimize the number of stops made by vehicles at stations and maintain faster average travel speeds.[73]

Implementation may include a contra-flow transit lane on Farnam Street in central Omaha, as specified in the City's TIGER grant application (2014). The contra-flow transit lane is a new design solution for Omaha and presents operational concerns at intersections. However, Metro expects the contra-flow lane will enhance system cohesion and economic development along the Farnam Corridor compared to an alternative implementation that would utilize standard curbside lanes along the Farnam/Harney one-way couplet. Strategies for addressing the issues raised by the contra-flow facility are not addressed in detail in the TIGER grant application, but the approach illuminates some of the motivations and risks associated with contra-flow transit lanes as a design option for one-way streets.[74]

Metro received a $14.9 million TIGER grant in 2014 from the US Department of Transportation for the project as well as substantial contributions from several private sources. The total projected capital cost of ORBT is $30.5 million,[75] suggesting a typical cost of about $3.5 million per mile. Planning for ORBT began before 2014. Construction was expected to start in Fall 2018 but had not commenced at the time of this report.



The ORBT project may include a contra-flow transit lane on a one-way street. The 2014 TIGER application provides diagrams illustrating the location and basic design of the contra-flow lane.

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[73] *Meet Omaha's new, faster bus to downtown: ORBT.* Omaha World-Herald. Accessed Feb. 18. https://www.omaha.com/news/metro/meet-omaha-s-new-faster-bus-to-downtown-orbt/article_1b0a5ede-82aa-11e7-bd5a-c3adf3e8d23c.html

[74] *Central Omaha Bus Rapid Transit – Connecting the Dots*. Transit Authority of the City of Omaha. Accessed Feb. 18. http://www.ometro.com/wp-content/uploads/2017/08/TIGER-Application.pdf

[75] *ORBT FAQs*. Transit Authority of the City of Omaha. Accessed Feb. 8. http://www.rideorbt.com/faq/

OMAHA ORBT CASE STUDY		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	Existing Route # 2: 1,750 daily boardings in 2015 (busiest in the system)
	Transit Mode Share	
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	10 mins during rush hour
	Transit Signal Priority	Yes. West of 30th St (non-downtown) only
	Person/Vehicle Delay	Construction of the BRT system will shorten travel along the corridor by 15.7 minutes.
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	
	Accessibility	Sixteen percent of households within one-quarter mile of the proposed BRT route do not have access to a vehicle and will benefit directly from increased access to jobs, activity centers, and medical facilities.
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	4 lanes + parking (one direction)
	Lane Width	10'6"
	Intersection Design	
	Separation of traffic	Business Access & Transit (BAT) lanes for 3.3 miles in downtown Omaha. Renders show red paint used to designate segregation.
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	$30.5 million ($15 million TIGER grant)
	Project Length	8.5 miles

Washington DC

In order to improve travel time reliability for buses plying along the most congested stretch of Georgia Avenue, a four-block (0.3 mile) section between Florida Avenue and Barry Place NW was reconfigured to include a bus priority lane.

This stretch is used by Metrobus routes 70 and 79, which carry more than 20,000 passengers from downtown Washington to Silver Spring, MD. This treatment is a part of a larger plan to overhaul the layout and reduce congestion along the entirety of Georgia Avenue.

This short section has included a transit priority lane since 2016. The right lane along the corridor is painted red with a double white line separating it from general-use lanes. The lane is designated primarily for use by buses (private or public). However, other vehicles can utilize the lanes, including emergency vehicles, paratransit vehicles, taxicabs, and bicycles as well as right turning cars at intersections.

While not all cities allow bicyclists in bus-only lanes, the Georgia Avenue red lanes feature shared-lane markings, as pictured above. The dashed white line indicates where drivers may enter the lane to make a right turn. Parking is not allowed along the corridor. Vehicle restrictions along the segment are enforced manually by officials, and violations can incur a $200 fine.

This section was implemented as a pilot or demonstration project, and the experience will be used to plan and implement similar transit priority treatments on other corridors in DC. There are plans to extend this section and implement a similar design on 14th St NW.

Source: Greater Greater Washington

WASHINGTON DC GEORGIA AVENUE CASE STUDY		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	Buses passing through this corridor carry more than 20,000 riders every day.
	Transit Mode Share	
	Traffic Volume	Before: 24,900 (2015) After: Not available (2017)
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	
	Transit Signal Priority	
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	Parking not allowed
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	Total ROW = 75'
	Lane Width	2 curbside Red lanes (12') + 2 mixed traffic lanes
	Intersection Design	
	Separation of traffic	Allowed in Bus lane: transit Buses, tour buses, charter buses, school buses, taxis, bikes, paratransit service vehicles, emergency vehicles, turning vehicles. The dedicated bus lanes are in effect Monday – Saturday between the hours of 7:00 am to 10:00 pm.
Other	Safety	
	Enforcement	Parking and turning movement violations $200. Monitored by officials.
	Maintenance	
	Cost	
	Project Length	0.5 mile

LITERATURE REVIEW

The RED Lanes Study literature review summarizes a broad body of literature on the topic of transit priority lanes and supporting corridor treatments. It synthesizes findings from numerous publications – several being research syntheses themselves – to highlight the major features of RED lanes and key contributors to their success. The literature review augments the real-world experience summarized in the case studies presented above with guidance generated by major research projects, guidebooks, synthesis reports, studies and plans from a variety of North American contexts. As such, the findings of the literature review frame generalized best practices and key considerations for RED lanes planning and implementation, regardless of regional size, transit system characteristics, or other considerations relevant to the selection of peer case studies. The findings address decision-making and planning frameworks for RED lanes, common measures for RED lanes evaluation, design considerations for implementation, and general rules for estimating RED lane benefits and costs.

The publications summarized below are selected from a much larger body of literature, an exhaustive review of which would constitute a significant investment in its own right. Selected articles and reports, however, cover a broad array of topics with clarity and appropriate depth for the purposes of the RED Lanes Study. Moreover, there is substantial cross-referencing across various reports, such that several summarized here capture the content of others not summarized. An additional reading list provided at the end of this section highlights other publications addressing RED lanes and related topics, but which were deemed not essential for the current study in light of the selected publications summarized. Interested readers are encouraged to explore these resources in addition to the selected publications for detailed information on a given RED lanes-related topic.

In the summaries of selected publications provided below, the RED Lanes Information Gathering Concept Matrix has been provided for those that have a comprehensive scope and synthesize research findings on the broad topic of transit priority lanes and related treatments. Other publications are focused on particular topics, such as enforcement, pavement treatments, or planning approaches; summaries of these documents are provided but a populated matrix has not been prepared.

SUMMARY OF KEY FINDINGS FROM LITERATURE

Before summarizing selected publications and highlighting their relevance to and guidance for RED lanes planning and implementation, this section distills the common themes and findings from the complete body of literature for brief summarization on specific topic areas, including:

- Decision-making frameworks for RED lanes
- Common metrics and criteria
- Design and operational considerations
- Costs and benefits of RED lanes

DECISION-MAKING FRAMEWORKS FOR RED LANES

There is a strong consensus among recent publications supporting a comprehensive approach in decision-making around the establishment of transit-supportive facilities, including transit exclusive and priority lanes. While the “warrants” for bus lanes first established in early TCRP publications (1970s) are still used, more recent publications recommend expanding the narrow focus from transit vehicle volumes and ratios of passenger throughput by mode to more comprehensive considerations, including policy-driven approaches. This trend in the literature is perhaps best summarized in TCRP Report 183: [76]

> *"A review of transit-supportive roadway strategies implemented by 52 transit agencies in the United States and Canada (Danaher 2010) found that nearly all considered multiple factors when evaluating strategies and did not apply the NCHRP Report 155 warrants."*

In providing guidance on decision-making criteria for transit lanes, TCRP 183 proposes using four criteria, identified in AASHTO's Transit Design Guide (2014)[77] in combination with four community factors developed by TCRP Report 183. The four factors from the AASHTO Transit Design Guide are:

1. *Provide priority to road users using less-polluting, more space- and energy-efficient, and less-costly (to society) travel modes.*
2. *Allocate roadway delay proportionally among all roadway users.*
3. *Protect the public investment in transit service.*
4. *Give an advantage to vehicles that maximize person throughput.*

Intended to supplement the factors above are the following four community considerations developed as part of TCRP Report 183:[78]

1. *Improvements to the community's mobility options.*
2. *Support for the community's long-term economic development vision.*
3. *Support for community goals to promote greater use of non-automobile modes.*
4. *Environmental impacts.*

Common Metrics and Criteria

There is no clear consensus for specific thresholds or warrants in selecting potential candidates for transit supportive facilities. TCRP Synthesis 83, which conducted a survey with numerous transit agencies, concludes that: "there are no standard warrants being applied to identify the need for particular treatments." However, several common themes do emerge from the literature as typical factors that should be considered. Indeed, in 2018, the Maryland Department of Transportation concluded in a literature review that, "Though there is no clear consensus on specific performance measures that should be used for selecting streets where dedicated bus lanes may work best, there are some clear considerations that must be considered." [79] Details of these key considerations vary depending on the specific application, location, and publication, but the following common measures/considerations appeared in most of the reviewed literature:

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[76] *TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies*, 2016. https://www.nap.edu/download/21929

[77] *Guide for Geometric Design of Transit Facilities on Highways and Streets*, 2014. https://store.transportation.org/Item/CollectionDetail?ID=133

[78] *TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies*, 2016. https://www.nap.edu/download/21929

[79] *Developing Dedicated Bus Lane Screening Criteria in Baltimore, Maryland.* Transportation Research Record, 2018. https://journals.sagepub.com/doi/abs/10.1177/0361198118797827

- Transit Vehicle Volume
- Person Throughput (by all modes)
- Safety
- Reliability/travel time variability/delay
- Automobile level of service (LOS)
- Physical/spatial considerations:
    - Available right-of-way (ROW)
    - Presence of parking
    - Access implications/access density

Specific examples of metrics developed for identifying and evaluating potential transit lanes are provided in this report in three literature summaries of projects conducted in Tampa, Miami, and Baltimore. Although there is not a consensus in the literature for specific thresholds, these applications provide examples of values deemed appropriate for their respective contexts and are useful as references when framing an approach to evaluating and prioritizing potential transit priority lanes in the CAMPO region.

Design and Operational Considerations

Transit Lane Width

There is a clear consensus among the literature reviewed that the recommended minimum width for a transit lane is 11 feet. In many cases, 12-13 feet is listed as the preferred lane width, and in some cases – especially where the lane is shared with bicyclists – up to 14.5 - 16 feet or more may be warranted.[80] However, as the case study section of this report has shown, there are numerous examples of transit priority lane implementations with narrower widths (sometimes as narrow as 10 feet).

Managing Turns and Shared Uses

The literature is clear that allowing non-transit uses in transit lanes reduces the time savings benefit to transit vehicles. TCRP Report 183 notes that time savings can be reduced by half when right turns are allowed in central business district areas.[81] However, the literature also indicates that the allowance of non-transit users – such as right turns, taxis, and bicyclists – can help build support in a community where transit vehicle volumes are relatively low or physical space allows for use by other modes/vehicles.

Red Surface Treatments

Throughout the literature, there is consensus that red surface treatments are a cost-effective component of transit priority-lane implementation that is effective at reducing violations by motorists or other restricted users. In general, red surface treatments are considered appropriate for full-time transit lanes; it's use for part-time transit priority lanes is less common and generally not recommended. Red can be used to designate either parts of or an entire corridor. It is important to note that because red surface treatments are not included in the MUTCD for the purpose of designating transit facilities, FHWA Interim Approval may be needed before applying red paint to a given corridor. TCRP 183 Appendix D contains information and a template for applying for this approval. [82]

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[80] Ibid

[81] Ibid

[82] *TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies*, 2016. https://www.nap.edu/download/21929

Transit Signal Priority Considerations

Transit Signal Priority (TSP) is widely considered in the literature reviewed to be an appropriate transit-supportive strategy in most urban environments. In general, TSP is most effective in environments where transit vehicles experience delay from congestion, but where congestion is not so severe as to prevent the transit vehicle from taking advantage of the TSP benefit. TCRP Synthesis 83 identified the following criteria as being best suited applications for TSP:[83]

- Level of Service (LOS): D and E
- Volume-to-capacity ratio (v/c): between 0.8 and 1.0

TSP can have an impact on vehicle traffic, especially along busy cross-streets. However, several studies reviewed in this report indicate that impacts are typically minor to negligible.

Enforcement

There is general agreement among the literature reviewed that a mixture of enforcement measures is needed, with an emphasis placed on the most cost-effective measures, such as red surface treatment and automated enforcement. Additionally, publications recommend engaging with all stakeholders involved in transit lane enforcement at all phases of a project.

COSTS AND BENEFITS OF RED LANES

Estimating Benefits

The literature review revealed several methods for estimating benefits form the installation of transit lanes. Perhaps the most widely used is the *Transit Capacity and Quality of Service Manual, 3rd Edition*, which includes the table below for estimating time savings based on several variable. The table shows bus travel times, in minutes per mile, based on different bus treatments and conditions.

Condition	Bus Lane	Bus Lane, No Right Turns	Bus Lane with Right Turn Delays	Bus Lanes Blocked by Traffic	Mixed Traffic Flow
CENTRAL BUSINESS DISTRICT					
Typical		1.2	2.0	2.5 – 3.0	3.0
Signals set for buses		0.6	1.4		
Signals more frequent than bus stops		1.5 – 2.0	2.5 – 3.0	3.0 – 3.5	3.5 – 4.0
ARTERIAL ROADWAYS OUTSIDE THE CBD					
Typical	0.7				1.0
Range	0.5 – 1.0				0.7 – 1.5

Source: TCRP Research Results Digest 38 (37)
Note: Traffic delays reflect peak conditions

Other methods for measuring benefits identified in this report include observed benefit surveys, which are reported in several of the literature review summaries, including TCRP Synthesis 83.

[83] *TCRP Synthesis 83: Bus and Rail Transit Preferential Treatments in Mixed Traffic*. Transportation Research Board (TRB), 2010. https://nacto.org/docs/usdg/tcrp_synthesis_83_danaher.pdf

Estimating Costs

This literature review identified several methods for estimating the cost of installing various transit-supportive facilities. The most authoritative source identified in this literature review is TCRP Report 90, which is reprinted in TCRP Synthesis 83. For the conversion of existing to transit only lanes, TCRP 90 estimates capital costs between $50,000 to $100,000 per mile. This estimate includes re-striping and signage. The cost for new transit lanes on urban streets is included in the below, originally published in TCRP 90.

Treatment	Capital Cost
Curb or off-set lanes	$2 to $3 million/lane-mile
Median transitway (bus)	$5 to $10 million/lane-mile
Median transitway (LRT)	$20 to $30 million/track-mile

TCRP 83 also includes Transit Signal Priority (TSP) cost estimates. TCRP 83 notes that signal upgrades can be under $5,000 per intersection if existing equipment can be utilized. When new equipment is needed, costs can be expected in the range of $20,000 to $30,000 per intersection.

PUBLICATION SUMMARIES

TCRP SYNTHESIS 83: BUS AND RAIL TRANSIT PREFERENTIAL TREATMENTS IN MIXED TRAFFIC

Transportation Research Board (TRB), 2010[84]

Report Summary

The purpose of this report is to synthesize all potential transit preferential treatments that have been or could be applied. Treatments reviewed in this report include:

- Roadway Segments: Median transitway, exclusive lanes outside the median area, and limited stop spacing/stop consolidation.
- Spot Locations (Intersections): Transit signal priority (TSP), special signal phasing, queue jumps

This summary focuses on the topics of exclusive lanes outside the median area and TSP.

Decision Framework for Transit Lanes

In making decisions around designating a transit lane, TCRP Synthesis 83 recommends an approach that considers the following questions as a decision-making framework:

1. Is the transit demand high enough to warrant service so frequent that exclusive transit lanes will be well-used and even self-enforcing?
2. Is there adequate roadway right-of-way available to develop a median transitway or added traffic lanes that could be dedicated to transit use?
3. Will the development of exclusive transit lanes still allow adequate local access in a corridor, recognizing that median transitways may block mid-block and unsignalized intersection left-turn access, and curbside transit lanes have to share the lanes with local driveway movements and right turns at intersections?

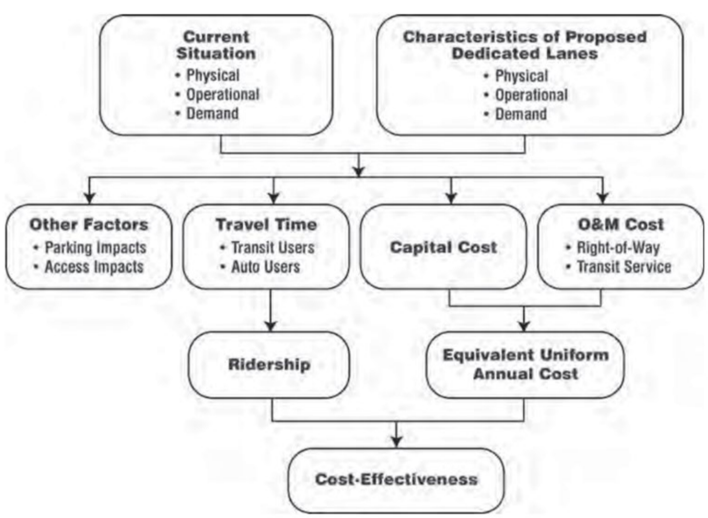

FIGURE 55 Evaluation process for dedicated transit lanes [*Source: TCRP Report 118* (*5*)].

[84] *TCRP Synthesis 83: Bus and Rail Transit Preferential Treatments in Mixed Traffic*. Transportation Research Board (TRB), 2010. https://nacto.org/docs/usdg/tcrp_synthesis_83_danaher.pdf

In addition, the report identifies a process for evaluating transit lanes from a cost-effectiveness and feasibility perspective. This framework, illustrated in "Figure 55," was first published in TCRP 118.

Decision Framework for Transit Signal Priority (TSP)

In considering TSP improvements on a corridor, the synthesis report lists six key considerations:

1. Are traffic conditions and transit volumes along a corridor currently within or projected to be within the "operationally feasible" range to successfully implement TSP?
2. Can TSP be implemented without creating unacceptable congestion on cross-streets?
3. Is it possible to implement an extended TSP treatment along a corridor with a median tramway or exclusive transit lanes and, if so, would it provide added benefit to warrant the added cost?
4. Can transit stops be located on the far side of an intersection, or mid-block, so that effective TSP can be provided?
5. Is the existing traffic signal control system capable of accommodating TSP, or are signal hardware and/or software modifications needed?
6. Will automatic vehicle location (AVL) or automatic passenger counters (APC) be integrated with transit vehicles, which will dictate whether conditional or unconditional TSP can be applied?

Similar to the transit lane framework, the report also identifies a decision-making framework for evaluating TSP candidates. This is illustrated below in "Figure 56," first published in TCRP 118.

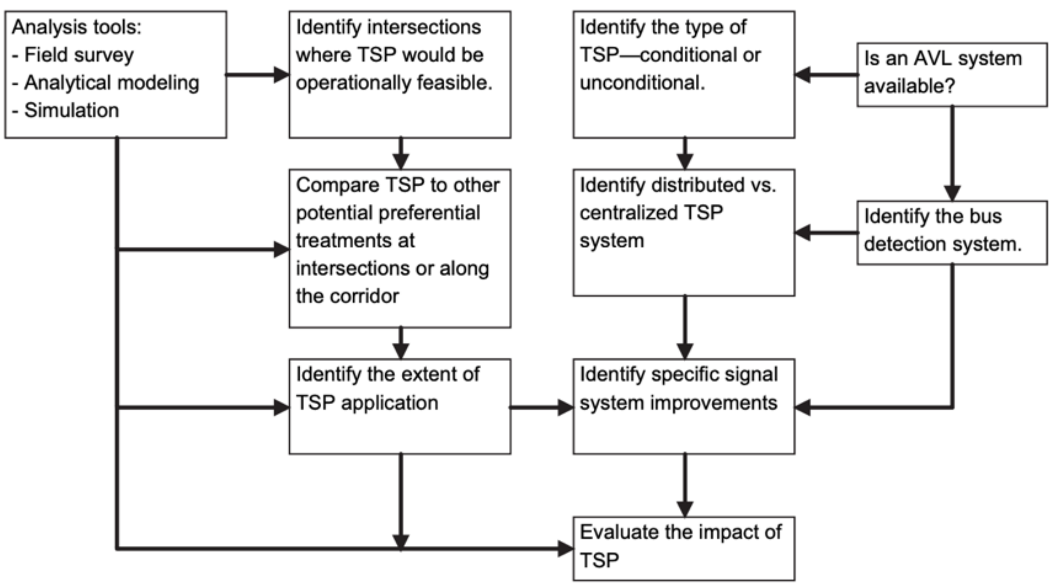

FIGURE 56 TSP decision framework [*Source: TCRP Report 118* (*5*)].

Transit Lane Suitability

As part of TCRP 83, a survey was conducted of transit agencies to identify warrants for transit priority treatments, including exclusive bus lanes. The table below reports survey findings by transit agency. The researchers note that "there are no standard warrants being applied to identify the need for particular treatments." However, several themes do emerge, including: "ridership, safety, and delay considerations, as well as reliability and level of service."

Although the survey did not find consensus around thresholds or warrants for transit lanes as applied today, TCRP 83 included a literature review that identified historical warrants used for bus lanes. The table below, adapted from this report, reviews these warrants.

Report	Metric	Proposed Warrants
NCHRP Report 143: Bus Use of Highways— State of the Art (1973)	Transit Vehicles Per Peak Hour	Minimum 60 transit vehicles per hour
	Ratio of riders in transit vehicles to drivers and passengers in automobiles	At least 1.5 times as many transit riders than drivers and passengers
NCHRP Report 155: Bus Use of Highways: Planning and Design Guidelines (1975)	Design Year One-Way Transit Vehicle Volumes Per Peak Hour (existing volumes at least 75% of design year volumes).	Curb bus lanes within central business district (CBD): 20-30 Curb bus lanes outside CBD: 30-40 Report recommends taxis be allowed to use bus lanes when peak hour transit vehicle volumes are less than 60.

Transit Signal Priority (TSP)

TCRP 83 notes that TSP is most effective at intersections with the following conditions:

- LOS most effective where TSP is between D and E, with limited benefits at LOS A through C
- Volume-to-capacity (v/c) ratio: between 0.8 and 1.0

It is noted that v/c conditions over 1.0 have been found to be ineffective, as transit vehicles have been found to be delayed too long to take advantage of the extended green time in the signal cycle.

Cost Estimates for Transit Lanes and TSP

The report highlights cost estimates first identified in TCRP Report 90 (2007). For the conversion of existing to transit only lanes, TCRP 90 estimates capital costs between $50,000 to $100,000 per mile. This estimate includes re-striping and signage. The cost for new transit lanes on urban streets is included in the below, originally published in TCRP 90.

Treatment	Capital Cost
Curb or off-set lanes	$2 to $3 million/lane-mile
Median transitway (bus)	$5 to $10 million/lane-mile
Median transitway (LRT)	$20 to $30 million/track-mile

TCRP 83 notes signal upgrades can be under $5,000 per intersections if existing equipment can be utilized. When new equipment is needed, costs can be expected in the range of $20,000 to $30,0000 per intersection.

Travel Time Savings Estimates for Transit Lanes and TSP

TCRP 83 synthesizes previously published time savings estimates from transit lanes and TSP. These estimates are illustrated below in the following tables from TCRP 83.

Location	Source	Travel time savings (minutes per mile)
Los Angeles – Wilshire Blvd.	Observed	0.1 – 0.2 (am) 0.5 – 0.8 (pm)
Dallas – Harry Hines Blvd.	Observed	1.0
Dallas – Ft. Worth Blvd.	Observed	1.5
New York – Madison Ave.	Observed	43% (express) 34% (local)
San Francisco – 1st Street	Observed	39%
Highly Congested CBD	Estimated	3 – 5
Typical CBD	Estimated	1 – 2
Typical Arterial	Estimated	0.5 - 1

Source: TCPR Synthesis 83, Tables 20, 27

Location	% Running Time Saved	% Increase in Speeds	% Reduced Intersection Delay
Anne Arundel County, MD	13 – 18		
Bremerton, WA	10		
Chicago, IL – Cernak Road	15 – 18		
Hamburg, Germany		25 – 40	
Los Angeles, CA – Wilshere/Whittier	8 – 10		
Pierce County, WA	6		
Portland, OR	5 – 12		
Seattle, WA – Rainier Ave	8		13
Toronto, ON	2 – 4		

Source: TCPR Synthesis 83, Table 22

TCRP SYNTHESIS 83: BUS AND RAIL TRANSIT PREFERENTIAL TREATMENTS IN MIXED TRAFFIC		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	Segment ridership > 100 per day
	Transit Mode Share	
	Traffic Volume	LOS C-D or LOS E-F w/ available ROW
	Non-Motorized Users	
	Person Throughput	Generally, a bus lane is justified when it can be expected to carry as many person trips as an adjacent general traffic lane, though some studies suggest 1.5 times the person throughput of an adjacent lane.
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	Numbers from reports vary: 25 buses per hour in a transit priority lane; 60 buses per hour in an exclusive lane. 60-90 buses per hour for transit-way; 40-60 buses per hour for contraflow lanes (20-30 for a short segment); 10-15 buses per hour for signal preemption, etc.
	Transit Signal Priority	Most effective at LOS D-E conditions with V/C ratios between 0.80 and 1.00. Limited benefit at LOS A-C. V/C > 1.00 may present long vehicle queues that limit the effectiveness of TSP.
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	Parking rarely allowed in bus lanes; offset or interior lanes are recommended to accommodate parking.
	Accessibility	
	Facility Functional/Access Class	Access density < 10 driveways per mile
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	There should be at least 2 lanes available for general traffic in the same direction, when possible.
	Lane Width	11' minimum width recommended
	Intersection Design	
	Separation of Traffic	
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	TSP can be <$5,000 per intersection if existing software/controller equipment can be used, otherwise $20,000 - $30,000. Conversion of existing lane to bus lane $50,000-$100,000 per mile; $2-$3 million for new construction.
	Project length	

TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies

Transportation Research Board (TRB), 2016[85]

Report Summary

TCRP 183 is intended to provide guidance around improving bus speed and reliability on streets, with a focus on creating streets designed for all users. The report includes specific strategies, decision making and operational guidance, and recommendations for changes to the Manual on Uniform Traffic Control Devices (MUTCD) intended to help facilitate the implementation of transit supportive designs. This review includes key findings from the report that address transit lanes and transit signal priority (TSP).

Decision Framework

The report proposes a comprehensive perspective in the selection of transit -supportive facilities as opposed to the more narrowly focused warrants developed in the previously published NCHRP 142 and 155. TCRP 183 states that "A review of transit-supportive roadway strategies implemented by 52 transit agencies in the United States and Canada (Danaher 2010) found that nearly all considered multiple factors when evaluating strategies and did not apply the NCHRP Report 155 warrants."

AASHTO's transit design guide, published in 2014, is cited as a recommended framework for identifying transit supportive facilities. This framework encourages the use of multiple decision-making criteria. The AASHTO guide identifies the following four criteria to be considered:

1. Provide priority to road users using less-polluting, more space- and energy-efficient, and less-costly (to society) travel modes.
2. Allocate roadway delay proportionally among all roadway users.
3. Protect the public investment in transit service.
4. Give an advantage to vehicles that maximize person throughput.

In addition to AASHTO's guidance, the report also recommends including the following community factors in making decisions:

- Improvements to the community's mobility options;
- Support for the community's long-term economic development vision;
- Support for community goals to promote greater use of non-automobile modes;
- Environmental impacts.

Strategy Selection

The report includes a Strategy Selection Matrix, intended to help practitioners identify specific transit supportive approaches to apply. The matrix reviews key costs, benefits, and related issues associated with various transit supportive strategies identified in the report. Three treatments – bus lane, red treatment, and TSP – are included in the table below, adapted from the original report. However, the full matrix can be viewed in TCRP 183 on page 45, Table 5.

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[85] *TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies*. Transportation Research Board (TRB), 2016. https://www.nap.edu/download/21929

Strategy	Bus lane, general	Red pavement	Signal priority
Typical Application	BRT, high bus volumes	Bus lanes	Signals
Traffic Volumes	V/C between .5 and 1.0	Any	V/C between .5 and 1.0
Bus Volume	Approx. 10-100 busses per hour	Any	<10 to 30 buses per hour
Bus Speed	Typical bus delay benefit, on a per-site or per block basis, between 15s and 60s	No effect	Typical bus delay benefit, on a per site or per block basis, of no effect to 15s (TCRP 183 Benefits section of TCRP 183 provides quantitative data on calculating this)
Bus Reliability	Relative impact on bus travel time variability is positive	No effect	Larger impact relative to other strategies
Auto Speed	Relative impact on automobile travel times - worsens automobile travel times to no effect.	No effect	Worsens travel time to improve travel time
Planning Costs	High planning costs	High planning costs	Moderate to high planning costs
Capital Costs	<$10,000 to >$100,000 capital costs	>$100,000 capital costs.	>$100,000 capital costs
Other Issues	Enforcement, part-time or conditional operation feasible	Support strategy that allows other strategies to work better, FHWA experimentation request needed	Part-time or conditional operation feasible, changes to traffic laws or design standards, signal controller capability

Transit Lanes Suitability

Although the guide does not propose specific "warrants," it does provide specific guidance around where transit lanes are suitable. The following three situations are proposed as being suitable for transit lanes:

1. On urban streets with relatively high bus and general traffic volumes, where many buses and their passengers are subject to delay;
2. In corridors with BRT or other premium bus service, where maximizing bus speeds and reliability is a priority; and
3. On shorter stretches of roadway, allowing buses to bypass a bottleneck or to move to the front of a queue (Kittelson & Associates et al. 2013).

Transit Lane Turning and Shared Uses

The report notes that although time savings from bus lanes are reduced by half when right turns by all vehicles are allowed in CBD areas, in some cases excluding right lanes is not feasible. In cases where right turns are allowed, the guidebook provides several strategies, including creating a right turn lane to the right of the bus lane, access management (in suburban areas), and ending the bus lane and instead implementing a signal modification at intersections. In cases where bus volumes are lower and policy support is not as strong, the guidebook recommends allowing other uses in bus lanes to build support.

Use of Red Surface Treatments

The report includes the use of red colored pavement – either for segments or the entire lane – as a transit-supportive strategy that reduces the number of violations of lane restrictions. The color is intended to supplement traditional signs and pavement markings, not replace them. The report indicates the use of red coloring in situations where the lane is "reserved exclusively or primarily for buses."

As of 2016, MUTCD did not permit the use of red treatments to designate transit lanes. However, TCRP 183 anticipates this to change in the next update to MUTCD. Further, the report notes that permission for red treatments have been applied – enabled with a FHWA Interim Approval – in New York City, San Francisco, Chicago, and Seattle. TCRP 183 Appendix D contains a "Request to Experiment Template," provides a model letter to request permission to apply red treatments to transit lanes.

Design Considerations

For bus lane width guidance, the guidebook references the AASHTO *Guide for Geometric Design of Transit Facilities on Highways and Streets* (2014), which allows bus lane widths to a minimum of 11 ft. In cases where bus lanes are shared with bicycles, the guidebook recommends 14.5 ft. to 16 ft. widths.

Duration of Restrictions

Transit priority lanes can be operated on a full-time or part time-basis. While full-time transit priority lanes provide the greatest benefit to transit performance and reliability, part-time lanes allow for other uses to take advantage of the right-of-way during off-peak hours. Uses permitted during off-peak hours can include parking, deliveries, and mixed-traffic operations. In cases where part-time operations are implemented, off-peak enforcement is required to minimize violations and ensure the right-of-way is available for transit use during peak hours.

Shared Uses and Right Turns

Transit priority lanes can be designated exclusively for transit vehicles, or other uses can be allowed to share the lane. Depending on the environment, right-turning vehicles, bicycles, or taxes may be allowed to share the right-of-way. Allowing other uses to share a transit lane can reduce the performance benefits realized by transit vehicles. For example, allowing right-turning vehicles has been shown to reduce transit speed improvements by nearly 50 percent. Shared uses should be considered in environments where transit volumes are low or where allowing other uses may help support implementation of the lanes. In cases where other uses are permitted, companion strategies should be considered to mitigate the impact. If right-turning vehicles can use the lane, strategies such as access management and queue jumps at intersections can reduce some of the performance impacts on transit.

Transit Signal Priority (TSP) Considerations

The guidebook notes that TSP generally reduces traffic delays on the intersection approach used by buses, thereby increasing bus speeds and improving travel time variability. The following general characteristics are provided to identify situations where TSP is suitable:

- Peak intersection v/c ratio between 0.6 and 0.9
- High transit ridership (existing or future)
- Generally, at least four buses per hour, but not too many buses to modify every cycle
- Intersections with far-side bus stops or bus stops that can be moved to the far side

Due to the cost in planning and implementation and the variances in outcomes of TSP installations, the guidebook recommends evaluating corridor characteristics, signal capabilities, bus stop locations, and signal spacing prior to the installation. In general, while the guidebook refers to *NCHRP Report 812: Signal Timing Manual* for further reference on TSP.

While most studies evaluating installations and simulations have found TSP to result in travel time savings for transit vehicles, the report notes that travel time savings are not always achieved. The report includes the followings reasons for why in some applications TSP may not achieve the desired benefit:

- Peak intersection v/c ratio between 0.6 and 0.9
- High Restrictions are too restrictive or not programmed correctly
- Bus schedules are not updated to reflect potential time savings, resulting in fewer late buses
- Incorrect locations selected for TSP
- Traffic congestion too high for buses to be able to take advantage of early or extended green.
- Too little traffic congestion to result in travel time savings
- Signal spacing too dense to result in overall time savings

TCRP REPORT 183: A GUIDEBOOK ON TRANSIT-SUPPORTIVE ROADWAY STRATEGIES		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	
	Transit Mode Share	
	Traffic Volume	V/C ratio between 0.5 to 1.0 for bus lanes, generally
	Non-Motorized Users	Shared lane with bicycles recommended where number of buses in lane is low or in constrained rights-of-way
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	Bus lanes usually have a positive effect on transit reliability. Magnitude of benefit varies.
	Transit Service Frequency	Observed bus volumes/recommendations range from 10 buses per hour to 100 buses per hour. Contexts vary.
	Transit Signal Priority	Typically strong benefit to transit and reliability, but modest impact on typical bus speeds. Apply in corridors with V/C ratios between 0.5 and 1.0, as higher V/C ratios reflect congestion levels that overwhelm TSP benefits. Suitable in corridors with fewer than 10 buses per hour. Can degrade auto travel time reliability.
	Person/Vehicle Delay	Transit lanes and TSP can degrade auto travel times and reliability but often have a negligible impact.
	Average Travel Speeds	Transit lanes improve bus travel times from 15 to 60 seconds per block, typically.
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	
	Accessibility	
	Facility Functional/Access Class	Bus travel time savings limited by right-turning vehicles in the bus lane. Driveway consolidations and other access management may optimize bus lane benefits.
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	11’ minimum; 12’-13’ recommended; 16’ for shared lane
	Intersection Design	
	Separation of Traffic	(See “non-motorized users” above)
Other	Safety	Facility and service design (speed limits, lane width, stop spacing, shared uses, etc.) are critical for safety.
	Enforcement	Red surface treatments reduce violations; violations undermine transit travel time benefits; full-time lanes are easier to enforce than part time lanes.
	Maintenance	
	Cost	Bus lanes can have high planning costs due to coordination and public engagement; capital costs roughly $10,000 to $100,000 per block.
	Project length	

Bus Priority Treatment Guidelines

Metropolitan Washington Council of Governments (MWCOG), 2011[86]

Report Summary

This report identifies a mixture of potential treatments for implementing previously designated transit priority corridors. Potential treatments explored in the guidebook include exclusive bus lanes, bus stop location, bus bulbs, queue jumpers, transit signal priority (TSP), bus stop design, and bus shelters. The guidebook recommends an approach that maximizes person throughput instead of focusing solely on LOS and volume-to-capacity (v/c) ratios.

Bus Lane Identification Criteria and Considerations

This document presents guidelines for the applicability of bus lanes based on the automobile Level of Service (LOS). For roadways operating at LOS A, B, or C, exclusive transit lanes are likely to be a feasible and appropriate solution. At LOS D, exclusive lanes may be an option, but restricted use lanes that have fewer impacts on adjacent traffic should also be considered. At LOS E or worse, traffic impacts from implementing an exclusive lane undermine potential benefits and are usually not appropriate.

The document also offers coarse guidelines for identifying bus lane needs based on several indicators:

- **Peak hour bus volumes**: 30-40
- **Passenger volumes**: 1,200 or higher per hour
- **Ratio of bus passengers to automobile passengers**: At least 1:1, looking at either existing and/or projected ridership

Design Considerations

The report notes that in some situations, only portions of a corridor need a designated bus lane for benefits to be achieved. Regarding transit lane width, the report notes that optimal width is between 12-13 feet. However, 11-12 feet is also considered acceptable. Paint and signage are important in the design and serve as low-cost forms of enforcement. However, the report notes that colored lanes are only appropriate in situations where restrictions on lane usage are in place at all times.

Enforcement

The report raises several considerations around enforcement, noting that designating an entity responsible for enforcement can be difficult, especially in multi-jurisdictional cases. The report recommends that during all project phases -- from planning to operations -- it is important to include all entities involved in enforcement activates and inform them of the costs and benefits.

Transit Signal Priority (TSP) Considerations and Applicability

In general, the report notes that TSP benefits transit at little cost to traffic. It provides several indicators that determine where TSP can be effective and should be applied. These indicators include:

- Bus delays are present due to heavy traffic congestion
- Most effective at intersections with LOS D or E
- V/C between 0.8 and 1.0 (TSP on corridors above v/c of 1.0 has been shown to be ineffective)

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[86] Bus Priority Treatment Guidelines Metropolitan Washington Council of Governments (MWCOG), 2011. https://nacto.org/docs/usdg/bus_priority_treatment_guidelines_national_capital_region_trans_planning_board.pdf

BUS PRIORITY TREATMENT GUIDELINES (MWCOG)		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	
	Transit Mode Share	Bus lanes warranted when peak hour bus volumes are between 30-40 buses per hour and passenger volumes are 1,200 or higher per hour in a corridor. Alternatively, bus lanes warranted when buses carry as many people as automobiles in adjacent lanes.
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	
	Transit Signal Priority	Most effective at LOS D-E conditions with V/C ratios between 0.80 and 1.00. Limited benefit at LOS A-C. V/C > 1.00 may present long vehicle queues that limit the effectiveness of TSP.
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	Maryland Complete Streets policies apply to bus lanes, loosening lane restrictions and allowing more users.
	Parking/Curb space	Parking should be removed form a street where an exclusive curbside bus lane is being considered under the following conditions: traffic volumes are between 500-600 vehicles per lane per hour, LOS for the street is E or F, and travel speeds fall below 20mph.
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	Bus lanes can be reversible and restricted to peak travel direction. This prioritizes buses in the peak travel direction and limits impacts on highway capacity.
	Lane Width	11' minimum; 12'-13' recommended.
	Intersection Design	
	Separation of Traffic	Restrictions most appropriate at LOS A-C, restricted or exclusive lanes at LOS D, exclusive lanes not feasible at LOS E or worse. Give consideration to delivery/municipal vehicles.
Other	Safety	Streets where parking has been removed to accommodate bus lanes have shown a reduction in collisions (15%-20%).
	Enforcement	Include enforcement partners early in the process. Passive enforcement lower cost than active enforcement (policing or video surveillance). Red surface treatments reduce violations.
	Maintenance	
	Cost	
	Project length	Bus lanes need not span the entire length of a corridor to confer benefits.

Surface Transportation Optimization and Bus Priority Measures: The City of Boston Context

A Better City, 2010[87]

Report Summary

The purpose of this report is to develop recommendations around the implementation of bus operations optimization measures in Boston, MA. Although the report's primary objective is not to perform an analysis and identify specific corridors for improvements, the report includes a literature review component that identifies best practices for a variety of bus treatments. Since this review has a more specific scope than the document, a focus was taken on sections of the report addressing transit way treatments, such as bus exclusive lanes, and transit signal priority (TSP).

Transitway Treatment Considerations

Transit running way treatments are one of the bus optimization measures reviewed in the report. The table below, reproduced based on Exhibit 5 in the report, shows the considerations identified as part of the report's literature review.

Type	Applicability	Potential Benefits	Potential Impacts	Considerations
Exclusive Lanes	High volume streets operating at levels of service A, B, or C	Improved bus schedule reliability, higher bus speeds	Reduction of private vehicle capacity or increased congestion of remaining mixed traffic lanes; elimination of curb parking spaces	Traffic impacts, reduction of parking capacity, turning movements
Restricted Lanes	High volume streets operating at levels of service A, B, or C	Improved bus schedule reliability, slightly higher bus speeds, HOV capacity	Less reduction of private vehicle capacity but risk of bus delays by HOV's; elimination of curb lane parking	Untrained drivers use of lane, signage, enforcement, safety and turning movements.
Unrestricted Lanes	High volume streets operating at levels of service E or F	Designated stop space, potential to provide a bus shelter and paved landing pad	Little to not improvement in bus operations	Unchanged operational environment for buses

Cost Estimates

The report identifies planning level cost estimates for the installation of bus lanes for scenarios where the lane is either existing, new, or is a median transitway. Cost estimates identified in the report are illustrated in the table below, reproduced based on Exhibit 11 (citing year 2003 values) in the report.

Treatment	Capital Cost	Operation and Maintenance
Existing lane converted to bus lane	$50k to $100k per mile	Minimal
Curb or off-set lanes	$2 to $3 million/lane-mile	Under $10k/lane-mile/year
Median transitway	$5 to $10 million/lane-mile	Under $10k/lane-mile/year

[87] *Surface Transportation Optimization and Bus Priority Measures: The City of Boston Context*. A Better City, 2010. https://www.abettercity.org/docs/Surface%20Transportation%20Optimization%20and%20Bus%20Priority%20Measures%20Final.pdf

Cost Effectiveness

The report offers a cost-effectiveness matrix intended to help frame various transit supportive measures based on its own extensive literature review. The report's findings are illustrated below in a table reproduced from Exhibit 28 in the report. This figure is intended to help frame the various types of bus priority improvements identified in the report in terms of relative costs and effectiveness. Although this matrix was developed with the Boston context in mind, the general concept is translatable to other areas.

EFFECTIVENESS	COST: Low	COST: Medium	COST: High
High	Stop Consolidation	Restricted Bus Lane	Exclusive Bus Lane Proof of Payment (PoP)
Medium	C2C TSP Stop Placement	Two-Door Boarding	
Low	Queue Jump	Curb Extension	

Corridor Evaluation Framework

Although the primary purpose of this report is not to identify and rank corridors for transit-supportive treatments/optimizations, the report does use several metrics to evaluate existing transit routes and highlight those that could benefit the most from transit optimizations. These include:

- Lowest average speed per segment (AM, PM, or all day).
- Greatest travel speed reductions identified in model forecast (from 2005 to 2015).

SURFACE TRANSPORTATION OPTIMIZATION AND BUS PRIORITY MEASURES: THE CITY OF BOSTON CONTEXT		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	An MBTA study evaluated the increase in ridership by route using the CTPS Travel Demand Model. Study ranked routes anticipated to experience the highest increases in ridership by percent increase.
	Transit Mode Share	
	Traffic Volume	LOS A-C
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	
	Transit Signal Priority	
	Person/Vehicle Delay	
	Average Travel Speeds	Study identified hotspots using average vehicle travel speed by segment. MBTA buses generally experience bus average bus speeds of approximately 11.4 MPH throughout the day (9.6 in AM peak, 8.4 in PM peak). Top 10 hot spots have transit speeds of 3.5 to 4.9 mph.
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	
	Intersection Design	
	Separation of Traffic	
Other	Safety	
	Enforcement	
	Maintenance	Existing lane converted to bus lane: Minimal Curb or off-set lanes: Under $10k/lane-mile/year Median transitway: Under $10k/lane-mile/year
	Cost	Existing lane converted to bus lane: $50,000 to $100,000 per mile Curb or off-set lanes: $2 to 3 million/lane-mile Median transitway: $5-10 million/lane-mile
	Project length	

Transit Street Design Guidelines: Transit Lanes

National Association of City Transportation Officials (NACTO) [88]

Report Summary

The National Association of City Transportation Official (NACTO) Transit Street Design Guide provides a framework for developing transit corridors. The guidebook offers considerations and recommendations with a focus on complete streets and comprehensive network considerations. Included in this review are guidebook highlights for the most common transit-exclusive and transit priority lane configurations.

Transit Lanes Suitability and Considerations

In general, the guidebook notes that transit lanes are well-suited for streets with high vehicle volumes and/or vehicle congestion in the context of downtown and/or corridor applications. It also states that decisions around implementing a transit lane should focus on the following factors, without being limited by any one factor:

- Transit volume (current and future)
- Transit demand (current and future)
- Potential to reduce total person delay
- Potential to limit increases to average travel time (both short and long-term)

In addition, the following indicators are suggested to identify streets that will realize the greatest benefits from transit lanes: travel time variability, travel time reliability, and boardings along the corridor. The guidebook recommends that Level-of-Service (LOS) analysis should be used only to consider queue lengths and potential network impacts and not for screening streets for applicability.

Transit Lanes Design

Transit lanes can be operated as full-time or part-time, depending on corridor characteristics. The greatest benefits are achieved with continuous lanes. Transit lanes should be designated with markings, signs, and regular enforcement. Red treatments are recommended to increase awareness. Desired transit lane width is 10-20 feet, depending on adjacent lane uses. A bus stop, for example, may only need 9ft, while a shared use lane with bicycles requires more than 14.5 ft.

Enforcement

The guidebook recommends automated enforcement as a preferred alternative to more expensive human enforcement. It also notes that full-time restricted lanes can reduce violations.

Managing Turns and Shared Uses

The guidebook recommends that turn management is necessary to preserve the benefits of transit lanes. Recommendations for managing turns include:

- Prohibitions on turning, which can be vital to preserving and enhancing transit performance.
- Accommodations for turns, including short facilities near intersections, such as right-turn pockets.
- Shared transit lanes with bikes and right turns.
- Dropping transit lanes at intersections.

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[88] *Transit Street Design Guide: Transit Lanes.* National Association of City Transportation Officials (NACTO), 2018. https://nacto.org/publication/transit-street-design-guide/transit-lanes-transitways/transit-lanes/

Transit Signal Priority (TSP)

The guidebook notes that TSP is a powerful tool for reducing transit vehicle delays by modifying traffic signal timing. The publication notes that some of the largest benefits are achieved in situations where TSP is implemented alongside other transit-supportive strategies, such as transit lanes. The guidebook notes that delays can be reduced by around 10 percent. At some specific intersections, transit delay reductions can reach 50 percent.

The guidebook provides characteristics of corridors where TSP should be included. General guidelines include situations where:

- Where transit delays are experienced are due to signals, with or without congestion.
- Intersections where the transit vehicle can reach the signal to take advantage of the extended green, in either mixed traffic or a dedicated lane or queue jump.
- Corridors with long signal cycle timings and/or large distances between signals
- Where turning transit routes can benefit from a special turn phase
- Corridors with moderate to long headways
- Intersections where a bus stop is, or can be, located on the far side

One challenge with TSP is the high level of coordination that is required between agencies for a successful implementation. Coordination is needed to make sure the technology on-board transit vehicles works with signal systems and schedules. In some cases, long-term agreements between the involved agencies is needed to ensure the system operates as intended.

TRANSIT STREET DESIGN GUIDELINES: TRANSIT LANES (NACTO)		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	Bus lanes implementation should be informed by multiple factors, with emphasis on transit volume, including future demand, and reduction in total person delay or limited increases to average travel time.
	Transit Mode Share	
	Traffic Volume	Streets with high traffic volume and congestion are good candidates for dedicated lanes, which organize traffic flow and improve on-time performance and transit efficiency. Auto LOS is not an acceptable planning factor when viewed in isolation. Its use should be limited to understanding queue lengths and other changes with potential network impacts.
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	Transit travel time variability and reliability over the day are a good indicator of the potential benefits of transit lanes, especially if boardings are consistent throughout.
	Transit Service Frequency	
	Transit Signal Priority	
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	Transit lanes are broadly applicable on downtown and corridor streets where transit is delayed by congestion and curbside activities, such as parking/standing.
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	
	Intersection Design	
	Separation of Traffic	
Other	Safety	
	Enforcement	Markings, signage, and enforcement maintain the integrity of transit lanes. Automated electronic enforcement, including license-plate readers or video, is preferable to labor-intensive patrols.
	Maintenance	
	Cost	
	Project length	

Bus Lane Enforcement Study

Metropolitan Washington Council of Governments (MWCOG), 2017[89]

Report Summary

The purpose of this study is to identify strategies that will lead to better compliance and enforcement of bus lane regulations. The study is based on a best practice reviews at a local and national scale and includes a benefit cost analysis. An implementation plan was then developed from these findings.

Stakeholder Coordination

The report emphasizes a need for cooperation during the entire implementation process between local and state agencies as well as between officials in traffic engineering, operations, and transit service planning.

FIGURE 2 KEY ELEMENTS TO EFFECTIVE BUS LANE IMPLEMENTATION

Enforcement

The study identifies both police and automated enforcement. Studies show that a perception of low enforcement levels for transit lanes leads to higher violation rates, indicating some level of police enforcement is needed. However, this comes at a cost. The study identifies automated enforcement as a more cost-effective option, however it notes that many times enabling legislation is needed.

Legislation

The study indicates that legislation is typically necessary to enable and implement a variety of enforcement-related activities, including reporting requirements, enforcement hours, fine amounts, etc.

Education

The study notes that education is a crucial component. The study recommends utilizing messaging during all phases of a project that is tailored to specific audiences that are relevant to the project. Additionally, it is recommended that education be provided directly to transit operators.

Monitoring

After a bus lane is implemented it is recommended that performance measures be identified to evaluate the lane. Metrics recommended include compliance and violation rates.

Benefit Cost Analysis

The report provides a high-level look at benefits and costs. Table 5 provides benefit-cost ratios for various transit lane implementation scenarios. This table is helpful in evaluating the cost-effectiveness of various treatment options. Table 3 and 4 provide cost units develops for the benefit-cost analysis.

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[89] *Bus Lane Enforcement Study*. Metropolitan Washington Council of Governments (MWCOG), 2017. https://www.mwcog.org/assets/1/28/10062017_-_Item_12_-_DO_NOT_PRINT_-_Bus_Lane_Enforcement_Study_Final_Report.pdf

TABLE 3 BCA COST ELEMENTS AND UNITS

Cost Element	Cost	Unit
Standard Bus Lane – White Pavement Striping (Capital Cost)	$100,000	Per Mile
Standard Bus Lane – White Pavement Striping (Maintenance Cost)	$10,000	Per Mile Per Year
Red Paint Bus Lane (Capital Cost)	$5	Per Square Feet
	$308,000*	Per Mile
Red Paint Bus Lane (Maintenance Cost)	$10,000	Per Mile Per Year
Manual Enforcement (Police enforcement)	$49.50	Per Hour
Bus-Mounted Camera Enforcement (Capital Cost)	$9,500	Per Bus
Bus-Mounted Camera Enforcement (Maintenance Cost)	$15	Per Bus Per Week
Stationary Camera Enforcement (Capital Cost)	$64,945	Per Camera
Stationary Camera Enforcement (Maintenance Cost)	$414	Per Camera Per Week

** Red paint needs to be re-applied every five (5) years*

TABLE 4 STRATEGIES AND ASSOCIATED ESTIMATED COSTS

Implementation Strategies[1]	Bus Lane Capital Cost ($)	Bus Lane Maintenance Cost ($/year)	Enforcement Capital Cost ($)	Enforcement Maintenance Cost ($/year)
Standard Lane Treatment - No Enforcement	$100,000	$10,000	-	-
Standard Lane Treatment - Low Manual Enforcement	$100,000	$10,000	-	$12,375
Standard Lane Treatment - Moderate Manual Enforcement	$100,000	$10,000	-	$49,500
Standard Lane Treatment - Maximum Manual Enforcement	$100,000	$10,000	-	$99,000
Standard Lane Treatment - Bus-Mounted Automated Enforcement	$100,000	$10,000	$142,500	$11,250
Standard Lane Treatment - Stationary Automated Enforcement[2]	$100,000	$10,000	$129,891	$41,382
Red Paint Bus Lanes[3] - No Enforcement	$308,000	$10,000	-	
Red Paint Bus Lanes[3] - Low Manual Enforcement	$308,000	$10,000	-	$12,375
Red Paint Bus Lanes[3] - Moderate Manual Enforcement	$308,000	$10,000	-	$49,500
Red Paint Bus Lanes[3] - Maximum Manual Enforcement	$308,000	$10,000	-	$99,000
Red Paint Bus Lanes[3] - Bus-Mounted Automated Enforcement	$308,000	$10,000	$142,500	$11,250
Red Paint Bus Lanes[3] - Stationary Automated Enforcement[2]	$308,000	$10,000	$129,891	$41,382

[1] Assumes one (1) year of implementation and operation along a one (1) mile corridor running with a frequency of fifteen (15) buses per hour
[2] Assumes two (2) enforcement locations per mile, and two (2) cameras per enforcement location
[3] Red paint needs to be re-applied every five (5) years

TABLE 5 IMPLEMENTATION ALTERNATIVES AND BENEFIT-COST RATIO

Implementation Alternative	Benefit-Cost Ratio (10 year)
Standard Lane Treatment - No Enforcement	0.90
Standard Lane Treatment - Low Manual Enforcement	1.66
Standard Lane Treatment - Moderate Manual Enforcement	3.09
Standard Lane Treatment - Maximum Manual Enforcement	3.01
Standard Lane Treatment - Bus-Mounted Automated Enforcement	7.87
Standard Lane Treatment - Stationary Automated Enforcement	4.82
Red Paint Bus Lanes - No Enforcement	1.50
Red Paint Bus Lanes - Low Manual Enforcement	1.71
Red Paint Bus Lanes - Moderate Manual Enforcement	2.51
Red Paint Bus Lanes - Maximum Manual Enforcement	2.31
Red Paint Bus Lanes - Bus-Mounted Automated Enforcement	4.06
Red Paint Bus Lanes - Stationary Automated Enforcement	3.13

Bus Lane Treatment Evaluation

New York City Department of Transportation (NYCDOT), 2012[90]

Report Summary

This publication documents research that utilized both long-term field observations and lab evaluations to identify the durability and skid resistance of surface treatments for red bus lanes in New York City. The report provides recommendations based on research findings on red surface treatments.

Research Findings and Recommendations

Based on lab and field observations, the study drew five overarching conclusions/recommendations:

- Products based on Portland cement are not effective on asphalt or cement surfaces.
- Products with a primary purpose of providing anti-skid surfaces accumulate dirt and degree.
- On asphalt surfaces, epoxy street paint products are durable.
- Asphalt concrete-based micro surfaces show potential.
- Surface pre-treatment, when done aggressively, improves epoxy street paint performance.

[90] *Red Bus Lane Treatment Evaluation*. New York City Department of Transportation (NYCDOT), 2012. https://nacto.org/docs/usdg/red_bus_lane_evaluation_carry.pdf

Report on the Efficacy of Red Bus Lanes as a Traffic Control Device

New York City Department of Transportation (NYCDOT), 2011[91]

Report Summary

This paper reports New York City Department of Transportation (NYCDOT) and Metropolitan Transportation Authority (MTA) findings around the effectiveness of using red colored pavement to designate exclusive bus lanes. After reviewing findings, the paper concludes that "red treatment is an effective and safe traffic control device suitable for inclusion in the Manual on Uniform Traffic Control Devices (MUTCD)."

Research Findings and Recommendations

The research identified several key findings and recommendations. These include:

- Designating bus only lanes with red paint reduces unauthorized driving and parking in bus lanes.
- Curb bus lanes that received a red treatment saw illegal standing reduced by 1/3
- Designating curbside bus lanes with red treatment did not reduce parking occupancy rates during periods when parking is allowed.

Designating bus lanes with red treatment did not significantly alter the portion of drivers who used the bus lane versus mixed lane for making right turns.

[91] *Report on the Efficacy of Red Bus Lanes as A Traffic Control Device*. New York City Department of Transportation (NYCDOT), 2011. http://stb-wp.s3.amazonaws.com/wp-content/uploads/2014/10/Summary-Red-Lane-Efficacy-Report-to-FHWA-v3.pdf

Primer on Transit Lane Conspicuity Through Surface Treatment

Transportation Association of Canada, 2010[92]

Report Summary

This report provides specific guidance on the benefits, cost-effectiveness, enforcement, and installation of red surface treatments to designate transit priority lanes. The findings, which are intended to inform and guide transportation professionals in Canada, are drawn from international research, including studies in the United States.

Red Surface Treatment Recommendations

The report notes that red surface treatments are the most cost-effective method for increasing motorist compliance is increasing the visibility of transit only lanes. It notes that studies in the United States, Canada, and internationally have found that red paint significantly decreases or eliminates transit lane violations. Several pilot projects in Canada have identified 50-100 percent reductions in violations

Red lanes reduce the need for police enforcement, but they do not eliminate it. Red surfaces should only be used to designate full-time, 24/7 transit lanes. Allowing cars to utilize red-colored lanes during parts of the day reduces their effectiveness.

Project Length and Duration

The project notes that it is not always necessary to use red surface the entire project length to designate transit only lanes. The UK, Australia, and New Zealand have found it to be sufficient to only use red surface to designate the beginning, middle sections, and end of transit lanes.

One strategy outlined in the report is limiting red surfacing to segments of a transit lane can be an effective strategy to reduce project costs. Additionally, red surface treatments can be used as a temporary measure for approximately 6-24 months when a new transit lane is introduced to help raise awareness. After this time frame, traditional signage may be sufficient in some circumstances.

Material Recommendations

The report provides some basic guidance into the use of red paint versus red colored materials, noting that:

- Red paint is less expensive and lasts approximately 3 to 5 years.
- Colored materials that require a new top layer are more expensive but last longer.

[92] *Primer on Transit Lane Conspicuity Through Surface Treatment*. Transportation Association of Canada, 2010. https://www.tac-atc.ca/sites/tac-atc.ca/files/site/doc/resources/primer-transit-conspicuity2010.pdf

Developing Dedicated Bus Lanes Screening Criteria in Baltimore, MD

Transportation Research Record, 2018[93]

Report Summary

This report reviews how Maryland Transit Administration (MTA), working with the City of Baltimore, developed performance measures and screening criteria for the identification of candidate bus lane corridors in Baltimore, MD.

Literature Review Findings

This study included a literature review and case studies. Although the report notes, "there is no clear consensus on specific performance measures that should be used for selecting streets," the literature review and case studies did identify several key performance measure themes, including:

- Frequency of service;
- Person throughput;
- Average speed and reliability;
- Automobile level of service (LOS).

The study also notes that "person throughput was perhaps the most useful performance measure for assessing how streets are currently being utilized, moving the conversation toward equitable transportation solutions instead of transportation by private vehicle."

Identifying Candidate Streets

In order to identify candidates for dedicated bus lanes, the Baltimore team developed a set of performance measures that were derived in part from the literature review findings. A tiered analysis was then used, beginning with the following general set of criteria to select the first 25 streets for consideration:

- relatively high frequency and ridership
- some level of travel time delay
- reliability issues

Preliminary Criteria

After the team identified a set of candidate corridors, a preliminary screening was developed. The preliminary screening criteria was comprised of the following factors:

- Level of bus service planned on a corridor
- Person throughput by mode
- Spatial feasibility

Detailed Screening

After the preliminary screening was conducted, a detailed analysis was then conducted on the remaining streets. The measures used for the full evaluation are documented in tables 4-6, from the report, reproduced below.

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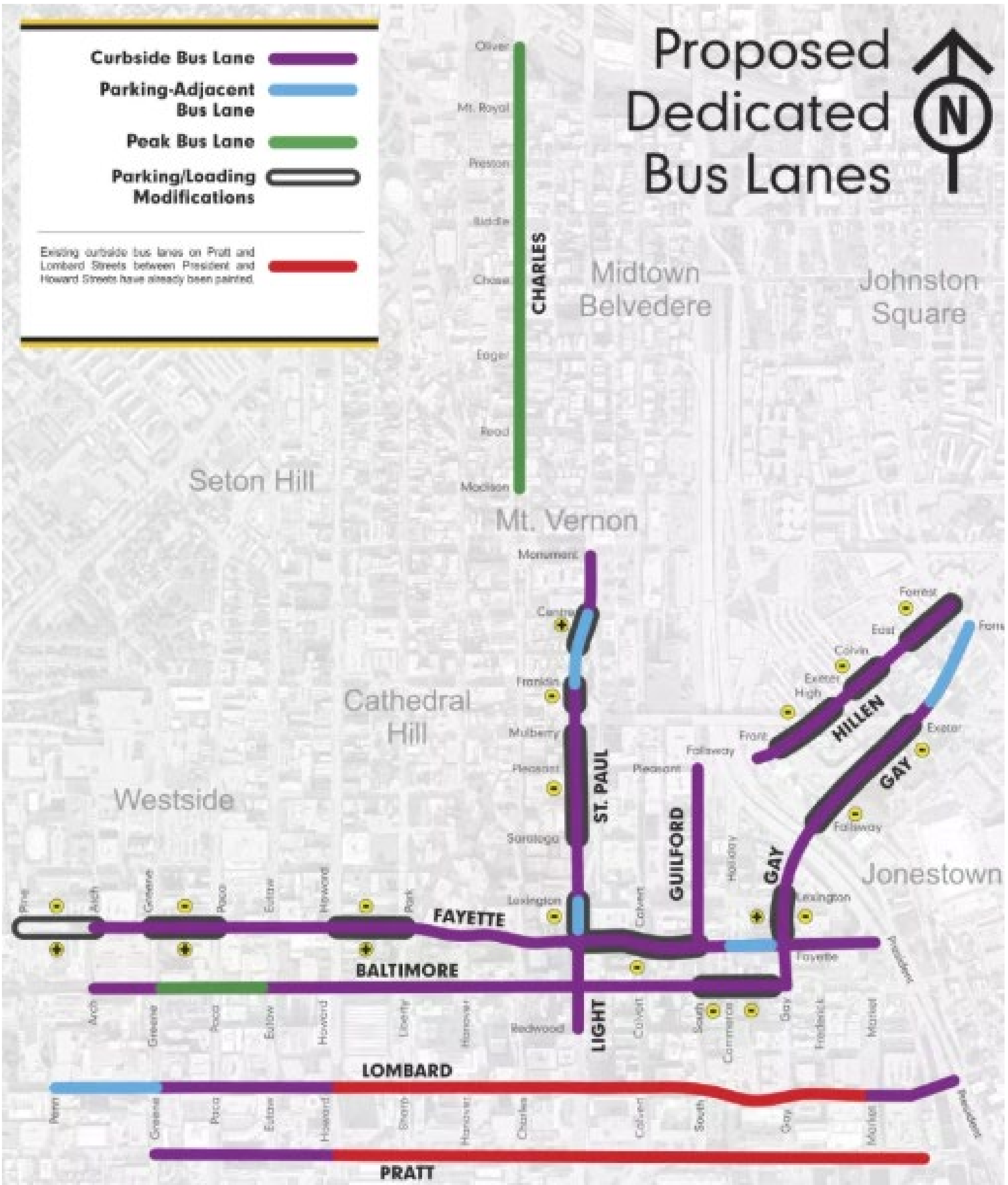
[93] *Developing Dedicated Bus Lane Screening Criteria in Baltimore, Maryland.* Transportation Research Record, 2018. https://journals.sagepub.com/doi/abs/10.1177/0361198118797827

Performance Measures	Auto	Transit
Person Throughput	Bus lane should carry approx. 80% to 120% of the adjacent auto lane. The flexibility/range allows for consideration of exclusive bus lanes, business access and transit lanes, peak period bus lanes, and use of consecutive turn lanes and on-street parking conversion.	
Person Delay	Change in person delay (passengers/riders/operators of autos and buses) with conversion to bus lane	
Volume (peak hour, peak dir.)/ Frequency	Peak hour: >1000 vehs requires more than 1 auto lane; Daily: >10,000 vehs requires more than 1 auto lane	Curb lane: >= 24 buses (1 bus every 2.5 mins); Offset lane (i.e., adjacent to parking): >= 18 buses (1 bus every 3.3 mins)
Passengers per hour	Not applicable (1.15 passengers per vehicle assumed systemwide per Baltimore Metropolitan Council)	Curb lane (CBD): 2,000 – 3,000; Curb (normal flow): 1,200 – 1,600; Offset lane (i.e., adjacent to parking): >800 (all expressed as peak hour)
Travel time	Projected impacts to be assessed on case-by-case basis, balancing need to move the greatest number of people	
Average speed	> 10 mph below speed limit: bus lane detrimental to corridor mobility; 0 – 10 mph below speed limit: bus lane may have limited mobility impacts; Additional case-by-case considerations given to intersection impacts	< 8 mph: substantial benefits to bus lane; 8 – 12 mph: potential benefits to bus lane; > 12 mph: limited benefits to bus lane; Additional case-by-case considerations given to intersection impacts and potential for transit preferential treatments (e.g., transit signal priority, queue jumps, etc.).
Level of service (LOS)/ delay and v/c	Expected change in LOS/delay and v/c (LOS/delay may be appropriate at LOS "E" [55-80 seconds of average vehicle control delay] if benefits to bus travel are substantial); v/c < 1.0	Expected change in delay
Parking and loading/ unloading impacts	Case-by-case basis to determine potential impacts; likely only applicable for curbside bus lanes, but consideration will also be given to any potential parking and loading/unloading impacts.	
Population near routes	NA	% relevant population accessed within 5-min walk of corridor, bus routes on corridor, or both.
Transit-dependent population near routes	NA	
Access to jobs	NA	# of jobs accessed by bus routes on corridor
Connectivity/transfers	NA	# of direct connections to high-capacity transit (i.e., Metro, light rail, CityLink).
Emergency routes	Yes/No	
Freight routes	Yes/No	
Lane width	10-12 ft: bus lane appropriate; 12-14 ft: consider painted buffer or consider bus/bike lane; >14 ft: consider separate adjacent bike(green) and bus (red) lane.	
Right turns at intersections	< 100 right turns per hour: motorists can use bus lane > 100 right turn lanes per hour: exclusive alternative should be considered (i.e., bus bypass lane, queue jump)	NA

Full Analysis and Recommendations

After the detailed screening was complete, the number of candidate streets was reduced to 10. The team then conducted a full analysis of the remaining 10 candidates. The goal of the full analysis was to identify the impact that adding bus lanes would have on parking and traffic operations. In order to identify the potential impact, the full analysis included a traffic operations analysis, including Synchro models, as well as evaluations of delay on automobile traffic, LOS, and volume-to-capacity metrics. The final output of this process was recommendations for dedicated bus lanes, illustrated below in a map provided in the report.



A map of bus-only lanes in downtown Baltimore (Source: Streets Blog USA)

HART Transit Corridor Evaluation and Prioritization

Detail Review from TCRP Synthesis 83, 2010[94]

Report Summary

Included in TCRP Synthesis 83 is a summary of a 2007 effort in Tampa, FL, to develop a scoring and ranking method to prioritize transit corridor enhancements for the Hillsborough Area Regional Transit Authority (HART) service area.

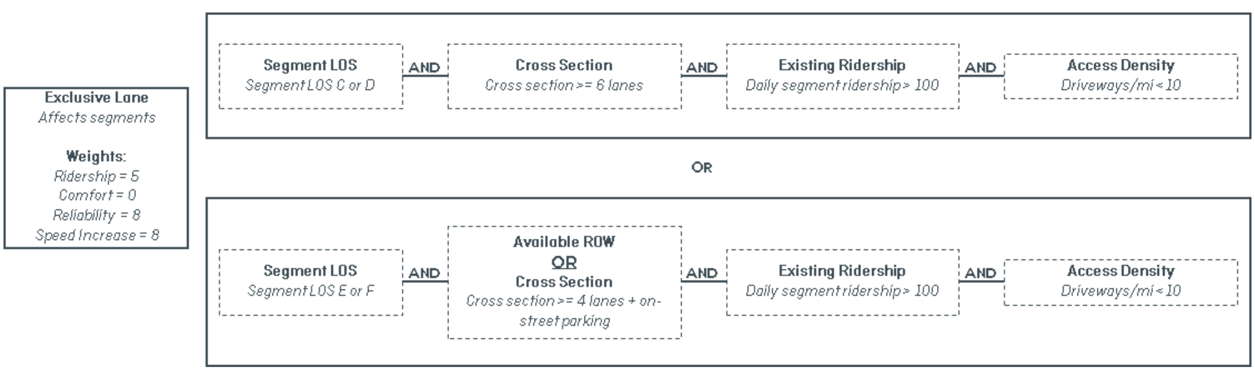
Evaluation Criteria

The study developed a method to evaluate bus treatments that followed three steps:

1. For each location (i.e., corridor segment, intersection, or bus stop), evaluate the factors described in Figure 54.) [*Note: the portion of this figure pertaining to exclusive transit lanes has been re-created below.]*
2. If all of the thresholds are met for a potential improvement at a given location, assign the weights for that potential improvement to the corridor for four different factors—increasing ridership, increasing travel speed (or decreasing delay), increasing passenger comfort, and increasing service reliability).
3. Sum the weights for each location in the corridor for use in corridor prioritization. The weights identified were based on a scale of 0 to 10, where 0 means that it would have no positive impact and 10 means it would have a significant positive impact.

Figure 54 of the synthesis report lists the factors used in step 1 of this process. The portions of this figure pertaining to exclusive transit lanes have been re-created below. Weights were assigned with values ranging from 0-10, with 10 indicating the highest level of positive impact. Total scores were normalized to adjust for varying lengths and densities of intersections and stops.

The authors of the synthesis report note that HART's application of the tool was "a technically sound, flexible, and objective evaluation methodology for prioritizing transit improvements and can serve as the foundation for subsequent policy discussions and decision-making." TCRP 83 suggests this approach "can be applied to the planning level evaluation and prioritization of corridors in any community."



[94] *TCRP Synthesis 83: Bus and Rail Transit Preferential Treatments in Mixed Traffic*. Transportation Research Board (TRB), 2010. https://nacto.org/docs/usdg/tcrp_synthesis_83_danaher.pdf

Bus Lanes in Downtown Miami

Miami-Dade TPO, 2015[95]

Report Summary

This report documents the development and application of a framework to identify bus corridors for potential transit treatments in Miami, FL. The study considers a variety of options for improving transit service, including transit way treatments, TSP, queue jumps, and stop consolidation.

Corridor Evaluation Framework

The study evaluates and maps existing corridors based on several factors, including bus volumes, turning movements, bus speeds, AADT, LOS, and street parking. A "hot spot" analyst was then conducted, which evaluated the bus network segments based on three variables:

- Number of daily bus trips by direction by segment;
- Number of daily boardings by direction by segment;
- Average peak period speed by direction by segment.

Each variable was assigned a score of 1-3. These scores were summed in order to identify the final "hot spot" corridors.

Estimating Costs

The study provides cost estimates for transit lanes. A cost of $200,000 per mile is used for this study in estimating the cost of converting an existing lane to a bus priority lane. Included in the cost estimate is adding appropriate signage and pavement markings.

Estimating Benefits

The study utilizes the *Transit Capacity and Quality of Service Manual, 3rd Edition*, to the estimate time savings benefits from the proposed transit lanes. Included in this summary is a reproduction of Table 4-2 from the report. The table shows bus travel times, in minutes per mile, based on different bus treatments and conditions. The study estimated time savings by calculating the difference (in minutes per mile) between two treatments. The study utilized the 1 minute per mile time savings achieved by a bus operating in a CBD bus lane with right turn delays versus a bus in a CBD mixed traffic lane.

Condition	Bus Lane	Bus Lane, No Right Turns	Bus Lane with Right Turn Delays	Bus Lanes Blocked by Traffic	Mixed Traffic Flow
CENTRAL BUSINESS DISTRICT					
Typical		1.2	2.0	2.5 – 3.0	3.0
Signals set for buses		0.6	1.4		
Signals more frequent than bus stops		1.5 – 2.0	2.5 – 3.0	3.0 – 3.5	3.5 – 4.0
ARTERIAL ROADWAYS OUTSIDE THE CBD					
Typical	0.7				1.0
Range	0.5 – 1.0				0.7 – 1.5

Source: TCRP Research Results Digest 38 (37)
Note: Traffic delays reflect peak conditions

[95] *Bus Lanes in Downtown Miami: Final Report.* Miami Dade TPO, 2015. http://miamidadetpo.org/library/studies/downtown-miami-bus-lanes-final-report-2015-12.pdf

Additional Reading

The table below provides a run-down of all the studies and publications considered for this literature review. The selections summarized above provide insight into a variety of key issues in RED lanes planning and implementation. Other reports provide similar valuable insight, but not all could be summarized adequately. Brief synopses are provided for each report to guide interested readers in additional potential RED lanes-related resources.

Document Name	Published By	Description	Document Focus
Mount Auburn Street Bus Priority Pilot: Questions & Answers https://www.cambridgema.gov/CDD/Projects/Transportation/~/media/57A6461830A84736802722B645AE9790.ashx	Cambridge Watertown BRT	Fact sheet about rollout of bus priority lanes in Cambridge, MA that allow bicycles and red turns for cars.	Case Studies
Developing Dedicated Bus Lane Screening Criteria in Baltimore, MD https://journals.sagepub.com/doi/abs/10.1177/0361198118797827	Maryland Department of Transportation (MDOT)	Approach to selecting corridors for dedicated bus lanes and other transit priority treatments.	Case Study
Red Colored Transit-Only Lanes Request to Experiment https://www.sfmta.com/sites/default/files/reports/2017/Red%20Transit%20Lanes%20Final%20Evaluation%20Report%202-10-2017.pdf	San Francisco Municipal Transportation Agency (SFMTA)	Example request to experiment used by San Francisco Municipal Transportation Agency (SFMTA) to propose experimenting with red colored transit-only lanes.	Case Study
Report on the Efficacy of Red Bus Lanes as A Traffic Control Device http://stb-wp.s3.amazonaws.com/wp-content/uploads/2014/10/Summary-Red-Lane-Efficacy-Report-to-FHWA-v3.pdf	New York City Department of Transportation (NYCDOT)	This report also includes a brief summary of an additional study by NYCDOT and the Pennsylvania State University on the application of red paint to designate transit lanes.	Case Study
Request for Information Regarding Red Bus Lane Treatments in New York City http://www.nyc.gov/html/dot/downloads/pdf/redbuslane_rfi_052710.pdf	New York City Department of Transportation (NYCDOT)	This Request for Information (RFI) has been issued to inform interested parties that the New York City Department of Transportation (DOT) intends to identify a set of best practices for the installation and maintenance of red-colored bus lanes in the City of New York.	Case Study

Document Name	Published By	Description	Document Focus
Shared-Use Bus Priority Lanes on City Streets: Case Studies in Design and Management https://nacto.org/docs/usdg/shared_use_bus_priority_lanes_on_city_streets_agrawal.pdf	Mineta Transportation Institute	Detailed case studies on the bus lane development and management strategies in Los Angeles, London, New York City, Paris, San Francisco, Seoul, and Sydney.	Case Study
Bus Lanes in Downtown Mami http://miamidadetpo.org/library/studies/downtown-miami-bus-lanes-final-report-2015-12.pdf	Miami Dade TPO	This study provides an assessment of existing transportation conditions in the study area for the Miami Downtown Bus Lanes Study and prioritizes potential corridors for transit-supportive improvements. The data provided is intended to provide the framework for the identification and evaluation of potential transit priority treatments in the downtown Miami area.	Decision Making
Transit Corridor Evaluation and Prioritization Framework https://trid.trb.org/view/776956	Transportation Research Board (TRB)	This report presents the evaluation methodology that was developed and used by Hillsborough Area Regional Transit (HART) (Tampa, Florida) to evaluate and prioritize key transit corridors, or Transit Emphasis Corridors (TECs). This methodology is a planning-level tool to verify if specific improvements relating to bus service, preferential treatment, and/or facilities are warranted. Although it requires tailoring, the methodology developed is intended to be applied by any community establishing priority corridors.	Decision Making
Transit Signal Priority Favorability Score: Development and Application in Philadelphia and Mercer County https://www.dvrpc.org/Reports/13033.pdf	Delaware Valley Regional Planning Commission (DVRPC)	Includes set of criteria for scoring transit signal priority (TSP) priorities within the DVRPC region. A set of criteria was compiled to assess likely TSP effectiveness along corridors in Philadelphia based on a review of industry best practices and available data sources.	Decision Making
Bicycle Policy & Design Guidelines Maryland State Highway Administration https://www.roads.maryland.gov/ohd2/bike_policy_and_design_guide.pdf	Maryland Department of Transportation (MDOT) State Highway Administration	Section 2.13 contains guidelines for Shared Bus/Bike lanes in Maryland.	Design Guidelines and Policy Analysis

Document Name	Published By	Description	Document Focus
Bus Priority Treatment Guidelines https://nacto.org/docs/usdg/bus_priority_treatment_guidelines_national_capital_region_trans_planning_board.pdf	Metropolitan Washington Council of Governments (MWCOG)	MWCOG guidebook reviewing guidelines, best practices, as studies, etc..	Design Guidelines and Policy Analysis
Curbside Management Strategies for Improving Transit Reliability https://nacto.org/wp-content/uploads/2017/11/NACTO-Curb-Appeal-Curbside-Management.pdf	National Association of City Transportation Officials (NACTO)	This paper provides examples of how cities have successfully changed curb use to support transit. It is focused on the types of busy, store-lined streets where high-ridership transit lines often struggle with reliability. These key curbside management strategies support reliable transit and safer streets in one of two ways: either by directly making room for transit, or supporting transit projects by better managing the many demands on the urban curb.	Design Guidelines and Policy Analysis
Designing Bus Rapid Transit Running Ways (APTA 2010) https://www.apta.com/resources/standards/Documents/APTA-BTS-BRT-RP-003-10.pdf	American Public Transportation Association (APTA)	Provides guidance on the design of running ways for bus rapid transit services, including bus lanes.	Design Guidelines and Policy Analysis
Enhanced Transit Corridors Plan Capital/Operational Toolbox https://www.portlandoregon.gov/transportation/article/640269	Portland Bureau of Transit	Design guidelines developed by the Portland Bureau of Transit.	Design Guidelines and Policy Analysis
Guide for Geometric Design of Transit Facilities on Highways and Streets (Chapter 4-2) (2014) https://downloads.transportation.org/TVF-1%20for%20SCOH%20Ballot/TVF-1%20Ch%204-7.pdf	American Association of State Highway and Transportation Officials (AASHTO)	Provides guidelines for dedicated transit lanes on highways and streets.	Design Guidelines and Policy Analysis
King County Metro: Transit Speed and Reliability Guidelines and Strategies https://kingcounty.gov/~/media/depts/transportation/metro/about/planning/speed-reliability-toolbox.pdf	King County	The Speed and Reliability Guidelines and Strategies is a guidance document that King County Metro (Metro), local jurisdictions, and other stakeholders can reference to improve the speed and reliability of transit service together.	Design Guidelines and Policy Analysis

Document Name	Published By	Description	Document Focus
Manual on Uniform Traffic Control Devices (FHWA 2009) https://mutcd.fhwa.dot.gov/	U.S. Department of Transportation	Discusses bus lane signs and pavement markings in chapters Chapter 2G and 3D.	Design Guidelines and Policy Analysis
Saint Paul Street Design Manual: Shared Bus/Bike Lanes (p.75) https://www.stpaul.gov/sites/default/files/Media%20Root/Planning%20%26%20Economic%20Development/Street%20Design%20Manual%20Final101416.pdf	City of St. Paul	Design manual that includes description, recommendations, design considerations for shared bus-bike lanes.	Design Guidelines and Policy Analysis
Shared-Use Bus Priority Lanes on City Streets: Approaches to Access and Enforcement https://www.nctr.usf.edu/wp-content/uploads/2013/12/jpt16.4_Agrawal.pdf	Journal of Public Transportation, Vol. 16, No. 4, 2013	This paper examines policies and strategies governing the operations of bus lanes in major congested urban centers where the bus lanes do not completely exclude other uses. The two key questions addressed are: 1. What is the scope of the priority use granted to buses? When is bus priority in effect, and what other users may share the lanes during these times? 2. How are the lanes enforced?	Design Guidelines and Policy Analysis
TCRP Legal Research Digest 42: Transit Agency Intergovernmental Agreements: Common Issues and Solutions http://www.trb.org/Publications/Blurbs/168256.aspx	Transportation Research Board (TRB)	Framework and guidance for intergovernmental agreements	Design Guidelines and Policy Analysis
TCRP Report 165: Transit Capacity and Quality of Service Manual, 3rd Edition http://www.trb.org/Main/Blurbs/169437.aspx	Transportation Research Board (TRB)	Contains methods for estimating bus speeds on on different types of bus lanes in different environments (chapter 6).	Design Guidelines and Policy Analysis

Document Name	Published By	Description	Document Focus
TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies (2016) https://www.nap.edu/download/21929	Transportation Research Board (TRB)	TCRP Report 183 is a resource for transit and roadway agency staff seeking to improve bus speed and reliability on surface streets while addressing the needs of other roadway users, including motorists, bicyclists, and pedestrians.	Design Guidelines and Policy Analysis
Transit and Bicycle Integration: 3.4 Shared Bus-Bicycle Lanes http://www.bettermarketstreetsf.org/docs/BMS_P2-3_BestPractices_12072011.pdf	San Francisco Better Market Street project	Best practices, case studies for shared bus-bike lanes (includes case studies from US and international cities)	Design Guidelines and Policy Analysis
Transit Street Design Guide: Transit Lanes & Transitways https://nacto.org/publication/transit-street-design-guide/transit-lanes-transitways/transit-lanes/	National Association of City Transportation Officials (NACTO)	Overview, analysis, considerations, and design guidelines for various types of transit lanes, transitways, including shared bus bike lanes.	Design Guidelines and Policy Analysis
Primer on Transit Lane Conspicuity through Surface Treatment https://www.tac-atc.ca/sites/tac-atc.ca/files/site/doc/resources/primer-transit-conspicuity2010.pdf	Transportation Association of Canada	Recommendations on surface material and installation practices around red lanes.	Design Guidelines and Policy Recommendations
Surface Transportation Optimization and Bus Priority Measures in the City of Boston Context https://www.abettercity.org/docs/Surface%20Transportation%20Optimization%20and%20Bus%20Priority%20Measures%20Final.pdf	A Better City	This report presents the results of the research conducted for the Boston Surface Transportation Optimization Pilot Study, which researched bus optimization measures to determine the current best practices employed domestically and internationally to improve bus operations. Based on this research, VHB developed a list of candidate measures that could be applied to improve travel times and reliability for buses operating in Boston.	Design Guidelines and Policy Recommendations

Document Name	Published By	Description	Document Focus
The identification and management of bus priority schemes: A study of international experiences and best practice https://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/centre-for-transport-studies/rtsc/The-Identification-and-Management-of-Bus-Priority-Schemes---RTSC-April-2017_ISBN-978-1-5262-0693-0.pdf	Imperial College London	Study identifies through surveys and interviews how bus priority systems are identified and managed. 14 global cities are reviewed, including cities in Asia, Australia, Europe and North America.	Design Guidelines and Policy Recommendations
Bus Lane Enforcement Study	Metropolitan Washington Council of Governments (MWCOG)	Guidelines around enforcement of bus lanes.	Enforcement Best Practices
A Summary of Design, Policies and Operational Characteristics for Shared Bicycle/Bus Lanes https://nacto.org/docs/usdg/summary_design_policies_and_operational_characteristics_bus_lanes_hillsman.pdf	Florida Department of Transportation (FDOT)	Report investigates design and operation of shared bicycle/bus lanes in municipalities in the US and internationally. Includes recommendations for Florida.	Research/ Synthesis
Bus Lanes with Intermittent Priority: Assessment and Design https://nacto.org/docs/usdg/bus_lanes_with_intermittent_priority_eichler.pdf	University of California, Berkeley (Masters Thesis)	Bus Lanes with Intermittent Priority (BLIP) provide a compromise between dedicated bus lanes and buses operating in mixed traffic lanes.	Research/ Synthesis
Effect of Transit Preferential Treatments on Vehicle Travel Time http://docs.trb.org/prp/16-1724.pdf	Transportation Research Board (TRB)	Study used VISSIM to evaluate benefits of TSP, queue jumps, and bypass lanes.	Research/ Synthesis

Document Name	Published By	Description	Document Focus
Operational Analysis of Bus Lanes on Arterials http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_26-a.pdf	Transportation Research Board (TRB)	This research analyzes the operation of buses along arterial street bus lanes, focusing on operating conditions in which buses have full or partial use of adjacent lanes, exploring the impacts of adjacent lanes on bus speeds and capacities, and deriving relationships and procedures for these impacts and interactions. The research demonstrates how increasing bus volumes can reduce speeds and how right turns from or across bus lanes can affect bus flow.	Research/ Synthesis
Planning for Dedicated Bus Lanes on Roads Carrying Highly Heterogeneous Traffic https://ageconsearch.umn.edu/bitstream/207621/2/2009_53_DedicatedBusLanes_paper.pdf	University of Minnesota	This paper is concerned with modification and validation of a recently developed micro simulation model of heterogeneous traffic flow and application of the model to study the impact of provision of reserved bus lanes on urban roads.	Research/ Synthesis
Red Lane Treatment Analysis https://nacto.org/docs/usdg/red_bus_lane_evaluation_carry.pdf	New York City Department of Transportation (NYCDOT)	This paper presents the methodologies and findings from a series of field and laboratory tests used to evaluate red bus lane treatments for NYCDOT.	Research/ Synthesis
TCRP Report 118 Bus Rapid Transit Practitioner's Guide https://nacto.org/docs/usdg/tcrp118brt_practitioners_kittleson.pdf	Transportation Research Board (TRB)	TCRP practitioners guide includes best practices, case studies, cost estimates, etc..	Research/ Synthesis
TCRP Synthesis 83: Bus and Rail Transit Preferential Treatments in Mixed Traffic (2010) https://nacto.org/docs/usdg/tcrp_synthesis_83_danaher.pdf	Transportation Research Board (TRB)	This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.	Research/ Synthesis
Transit Signal Priority (TSP): A Planning and Implementation Handbook https://nacto.org/docs/usdg/transit_signal_priority_handbook_smith.pdf	Gannett Fleming, Inc/USDOT	TSP technical guidance, good references to other sources.	Research/ Synthesis

Document Name	Published By	Description	Document Focus
Urban Transit Priority Corridors: A Rapid Red Lane to Benefits http://docs.trb.org/prp/16-6237.pdf	Transportation Research Board (TRB)	This paper examines the benefits and costs of a proposed 2.2-mile transit priority corridor in San Francisco. The corridor includes transit only lanes, transit priority signals, and bus stop and pedestrian improvements.	Research/ Synthesis

Report 2: KEY Plans in the CAMPO Region

KEY PLANS IN THE CAMPO REGION

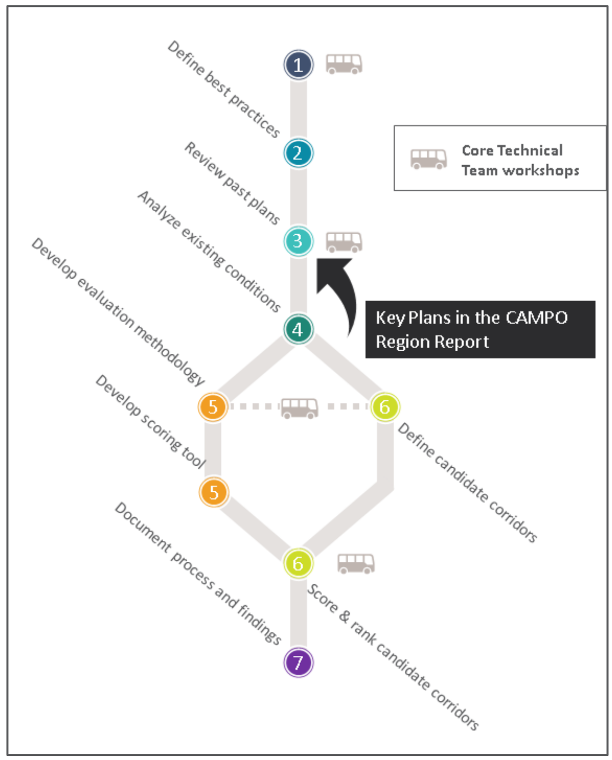
An Existing Plans and Studies Relevant Recommendations Report – Part of the CAMPO RED Lanes Study

INTRODUCTION AND SUMMARY OF CONTENTS

PURPOSE OF REPORT

The CAMPO RED Lanes Study is taking a comprehensive look at transit priority lanes as a potential part of the region's approach to enhancing its transportation system to meet growing demand, improve transit operations, and diversify modal options for local and regional travel. The RED Lanes Study report, "RED Lane Fundamentals," (under separate cover) describes the costs, benefits, design and operational features of RED transit priority lanes, while also defining best planning and implementation practices based on past experience in other regions. In considering the application of transit priority lanes in the CAMPO region, it is also important to understand their relationship to existing and ongoing plans and studies in the region.

This report summarizes key plans and studies from throughout the region and their relevance to planning for transit priority lanes. It highlights the major themes and emphases of recent planning efforts and identifies how these might inform the development of a RED lanes evaluation process. It also includes considerations for the design and implementation of RED lanes based on regional standards and identifies candidate corridors in the CAMPO region for RED lanes evaluation.



This report is an early step in the development and testing of a RED lanes evaluation process for the CAMPO region, focusing on relevant past plans and studies.

REPORT STRUCTURE

This "Key Plans" report is organized into three major sections. The first section summarizes key findings from a thorough review of planning documents from throughout the region. It highlights common themes and goals relevant to evaluating and planning for transit priority lanes.

The second section provides a plan-by-plan summary of key plans reviewed for this report. Each planning document reviewed is briefly summarized, highlighting its major points of emphasis and relationship to transit priority lanes. The reviewed plans are broken down into three categories:

- **Core Plans** and Studies are comprehensive in geographical scope, applying to the region as a whole or a significantly-sized sub-area (Wake County, e.g.) and having a stated or implied focus on multimodal transportation. Summaries of these plans include notes organized into the RED Lanes Information Gathering Concept Matrix, described in the "RED Lanes Fundamentals" report. In this report, the concept matrix organizes key findings from a given planning document into five major topic areas – demand, operations, design, contexts, and other – each having a set of indicators/sub-topics to consider. No single plan addresses all topic areas. The inclusion of the matrix provides an at-a-glance summary of Core Plans and Studies to facilitate understanding of the emphases of these major planning efforts that relate to the RED Lanes Study. *Note: In general, all plans emphasize safety, but the most relevant safety recommendations pertaining to RED lanes are generally focused on facility design and operations. As such, safety-related notes in the matrix are typically found in the operations and/or design topic areas rather than the safety sub-topic.*
- **Complementary Plans and Studies** include corridor and sub-area studies of regional significance, the most relevant of which focus on BRT or multi-modal travel in an area. Several studies are included that focus on rural and suburban corridors. Although these generally have only a modest transit component, they are included because of the broad regional emphasis on increasing multi-modal travel choices and in recognition of the potential for evolving local priorities and/or localized delay mitigation through innovative strategies such as RED lanes.
- **Ongoing Plans and Studies** remain unfinished but are important to recognize as potential sources of fresh information regarding the vision for a portion of the CAMPO region. Most of these studies are focused on specific corridors or subareas, and many have a transit emphasis. They also suggest corridors or areas that should be included as candidate RED lane corridors, potentially allowing the findings of this study may inform the ultimate recommendations of the ongoing studies.

Additional studies considered but not reviewed for this report are included in an "additional reading" list at the end of the second section.

Finally, the third section highlights corridors throughout the CAMPO region that are potential candidates for RED lane evaluation and prioritization, to be completed in a subsequent phase of the RED Lanes Study. This final section includes a brief description of how and why these corridors were selected based on the reviewed planning documents and other relevant planning and programming sources.

KEY FINDINGS

This section summarizes the major themes and emphases of the entire collection of planning documents reviewed for this report. It distills these plans into topic areas and planning priorities to encapsulate the relevant directives from planning efforts throughout the region as they relate to transit priority lanes. These key findings will be used to inform the development of a RED lanes evaluation methodology and potential implementation considerations. The plans reviewed also provide sources for identifying potential candidate corridors for RED lanes and related transit priority treatments, as described in the final section of this report.

Common Themes

Collectively, the plans reviewed for this report reveal several key emphasis areas of regional planning that can be organized into five primary topic areas.

Create a multimodal transportation network

- Many plans emphasize complete streets design principals, creating facilities that are safe and comfortable for all users. For many facilities, this includes designated space for transit vehicles, including transit priority lanes.
- Numerous plans, especially those with a regional scope, emphasize developing viable alternatives to auto travel and multi-modal strategies for congestion relief. They generally point to a need for greater connectivity among the region's centers via transit as well as non-motorized local connections.
- Sidewalks and bike lanes are important components of many plans, especially those focused on a specific corridor or sub-area. As the region grows, appropriate accommodation of non-motorized users will be increasingly important. RED lanes and related strategies should consider opportunities to accommodate these modes, such as allowing bicycles in RED lanes, for example.

Provide high quality transit on key corridors

- Several plans – most notably the Wake Transit Plan – call for significant augmentation to the regional bus network. This includes the designation of several BRT corridors, some of which are the subject of ongoing studies. RED lanes may be a supportive strategy in BRT implementation, either as a component of a BRT project or as a stepping stone to eventual BRT implementation in a corridor.
- The Wake Transit Plan also focuses on high-frequency fixed route local bus service. High-frequency services should operate at headways of 15-minutes or shorter to minimized wait times for transit patrons. Urban corridors not designated for BRT are strong candidates for high-frequency local bus, and RED lanes can play an important role in ensuring competitive and reliable travel times, especially when these corridors commonly experience congestion and/or delays at intersections.
- Finally, regional jobs and community centers should be connected by less-frequent (30- to 60-minute headways) by express and/or local bus services. These services will focus on jurisdictions and subareas with adequate population and/or employment density to support the transit service. While the corridors on which these routes would operate are unlikely to support RED lanes along their entire length, short treatments may alleviate delays at key bottleneck locations to maintain competitive travel times.

Reduce congestion on all roads, especially those providing key regional connections

- Although many plans emphasize increasing multi-modal options, they also acknowledge the automobile as the dominant mode for regional mobility and the need to continue to invest in highways to meet the region's travel needs while diversifying options over time.

- Congestion relief may be aided by multi-modal enhancements, including RED lanes, but in many cases, roadway widenings and new road construction will provide the primary mobility benefits needed in the region. In the right contexts, these projects may examine RED lanes as a potential design alternative.
- Generally, RED lanes should be considered where high frequency transit service is provided or planned, where sufficient right-of-way is available, and where the transit lane can reasonably be expected to provide a comparable level of person throughput to a general use lane.
- Operational and technological solutions may help to mitigate congestion without the addition of new roads or lanes. When planning for operational improvements to a corridor, transit signal priority (TSP) systems should be evaluated for potential travel time savings and reliability benefits for transit users.[1]

Improve safety and mobility for all modes

- All plans emphasize safety, aiming to reduce incidents and minimize risk to all travelers. In many cases, safety is addressed through operational and design enhancements to facilities or intersections.
- Several corridor and sub-area studies identify intersection or interchange design changes to reduce congestion and ensure safe travel along a corridor. In some cases, non-traditional designs could pose challenges for RED lane implementation. For example, a displaced left turn may be difficult to access from a curbside transit lane. Future consideration of facility and intersection design should consider the operational implications for buses in RED lanes in high-scoring candidate corridors.
- Another design approach to enhancing safety focuses on access management, including turning restrictions and driveway/parking consolidation. This facilitates more continuous traffic flow along the facility and reduces potential collisions. Since RED lanes often allow turning vehicles to utilize the transit lane, this strategy may be appropriate in RED lane corridors, especially as high volumes of turning vehicles can undermine the travel time benefits to transit vehicles in the RED lane.

Integration of land use and transportation plans

- Increasingly, planning documents are directly addressing the connection between land use or land development patterns and transportation system design and performance. Many plans in the CAMPO region acknowledge this connection and call for context-sensitive strategies that accommodate/prioritize modes and movements appropriately based on built environment characteristics that extend beyond the limits of the right-of-way.

[1] This study is not focused on TSP except as a potential component of optimal RED lane implementation. As such not all corridors being studied for operational improvements are considered candidate corridors for RED lanes, but only those having other attributes suggesting the potential implementation of a RED lane (with a potential TSP component) as a viable strategy. However, this finding may have significance beyond the scope of the current study as TSP can provide transit travel time benefits even in the absence of a RED lane.

- High-quality transit service is planned in areas that currently have or are planned to have high density development. Density is a key consideration for stop spacing, on-street parking, bicycle and pedestrian facilities, and other facility characteristics that could impact the viability and/or ultimate design of a RED lane.
- Transit-oriented development (TOD) has emerged nationally as important growth strategy, and several plans in the CAMPO region emphasize TOD to concentrate new development in strategic locations to optimize existing infrastructure and enhance transit utilization.

Implications for RED Lanes Evaluation

The RED Lanes Study will develop an evaluation/prioritization methodology to rank corridors throughout the region on their suitability/readiness for RED lanes or other transit priority improvements. Based on the summary of key plans, a RED lanes evaluation/prioritization approach should focus on the following key considerations/locations/designations (organized according to the RED Lanes Information Gathering Concept Matrix Topic Areas):

- Demand
  - Corridors serving **high ridership** routes or expected to accommodate high volumes of transit passengers through the confluence of multiple routes should be elevated in the prioritization process. Ridership estimates may be based on existing data or forecasts.
  - Transit plans in Wake County have consistently cited **25 passengers per revenue hour** as a critical ridership threshold for high-frequency transit services and transit priority treatments. This figure has been quoted for route performance evaluation but may also be applied in a corridor basis (accounting for multiple routes using the same corridor) in the RED lanes evaluation.
  - The GoTriangle Short Range Transit Plan (2018) acknowledges the difficulty of serving commuting demand from Durham and Orange Counties to Wake County since trips originate from many disparate locations. This may prompt an initial emphasis in RED lane planning on corridors with **primarily local fixed-route bus service and BRT plans** focused on CAMPO jurisdictions. It may be appropriate to elevate such corridors in the prioritization process above those primarily serving long-distance commutes and monitor shifts in transit service and demand for long range trips from Durham and/or Orange Counties over time.
- Operations
  - Weight should be given to segments identified as **bottlenecks** or otherwise posing delays to transit vehicles. The derivation of scores for such segments should consider the magnitude of typical delay, the frequency of transit service and ridership trends, and the potential travel time benefit(s) of RED lanes.
  - The prioritization process should consider routes or segments with observed **on-time performance or travel time reliability issues**, to the extent such data are available.
  - Buses should operate at **15-minute headways** (or more frequently) during peak periods on priority corridors. If a given RED lane project is seen as a pre-cursor to BRT, a target average travel speed of 16 miles per hour may be considered based on regional standards but is not required due to the operational differences between BRT and RED lanes.

- Contexts
    - Urban corridors in **moderate- to high-density areas** are the most appropriate corridors for RED lanes and other transit priority treatments. Other corridors would be expected not to perform as well in the prioritization process.
    - It would be appropriate to identify corridors or segments in areas identified for high density growth, TOD station areas, and/or locations with form-based codes or complete streets policies to reflect future transit ridership potential. **Multi-modal supportive policies** provide the appropriate contexts for RED lanes and will maximize their effectiveness.
    - It may be appropriate to identify **connectivity gaps** that could enhance accessibility via transit mobility/connectivity as potential areas for RED lane implementation.
    - The process should focus on the arterial roadway network rather than limited access highways such as interstates (I-40) or toll facilities (NC-540). The implementation of "managed lanes" on these facilities requires consideration of high-occupancy vehicle (HOV) and value pricing elements that are broader than transit vehicle design and operations on arterials. Limited access highway treatments such as the Bus on Shoulder System (BOSS) already allow some routes to operate on highway shoulders at safe speeds to bypass congestion and maintain competitive travel times.

Implications for RED Lanes Design and Implementation Considerations

While the RED lanes evaluation/prioritization process will highlight corridors with the highest suitability for RED lane implementation, the specific design choices and components of each facility will vary on a case-by-case basis. The review of regional, corridor, and subarea plans define the following service and facility design elements for BRT (generally based on the Wake Transit Plan BRT Design Standards and Performance Measures). A similar table could be developed for RED lanes as part of a later phase of the RED Lanes Study. Some topics included in the BRT standards may not be relevant to RED lanes, such as bicycle parking and level boarding requirements. The indicators thought to be most relevant to RED lane implementation are included in the RED Lanes Information Gathering Concept Matrix, which has some overlap with the BRT design standards and performance measures. Certain feature requirements, performance measures, and criteria thresholds are generally more rigid for BRT than for other transit priority treatments, due to funding requirements. As such, a similar table for RED lanes would probably include a different set of considerations and offer ranges of guideline values as opposed to "standards" per se.

Consideration	BRT
Ridership	25 passengers/revenue hour for weekday service
Average transit vehicle speed	16 mph
Transit Signal Priority	Applied at all intersections where a travel time savings can be demonstrated/ modeled
On-time performance (-1/+5 minutes of scheduled time)	85%
Queue jumps	At major intersections where dedicated running way is unavailable
Stop spacing (stops per mile)	2 in moderate/high density areas; 1 in low density areas
Length of dedicated running way	50% of route length
Branded stations	Yes
Off-board fare payment	Ticket machines at all stations
Real time arrival information	Yes
Schedule and route information	Yes
Enhanced comfort (large shelters and lighting)	Yes
Bicycle parking	Yes
ADA accessibility	Yes
Level boarding	Yes
Span of service	Weekdays: 5 am to 12 am Weekends: 6/7 am to 12 am
Frequency of Service	Early/late/weekends: 20 minutes All other times: 15 minutes
Vehicle loading maximums	120% peak commuting periods; 100 percent all other times
Operating costs per boarding	$6.00
Farebox recovery	20%

SUMMARIES OF KEY PLANS

Core Plans and Studies are comprehensive in geographical scope, applying to the region as a whole or a significantly-sized sub-area (Wake County, e.g.) and having a stated or implied focus on multimodal transportation. The documents reviewed in this section include:

Complementary Plans and Studies include corridor and sub-area studies of regional significance, the most relevant of which focus on BRT or multi-modal travel in an area. Several studies are included that focus on rural and suburban corridors. Although these generally have only a modest transit component, they are included because of the broad regional emphasis on increasing multi-modal travel choices and in recognition of the potential for evolving local priorities and/or localized delay mitigation through innovative strategies such as RED lanes.

Ongoing Plans and Studies remain unfinished but are important to recognize as potential sources of fresh information regarding the vision for a portion of the CAMPO region. Most of these studies are focused on specific corridors or subareas, and many have a transit emphasis. They also suggest corridors or areas that should be included as candidate RED lane corridors, potentially allowing the findings of this study may inform the ultimate recommendations of the ongoing studies.

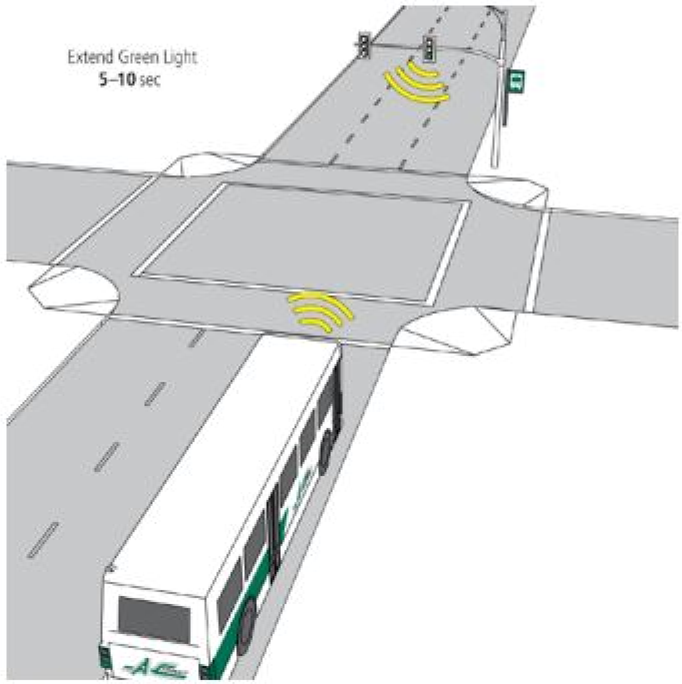
The table below provides a list of the plans and studies summarized with page numbers for reference.

Core Plans and Studies

Wake County Transit Plan Major Investment Study: BRT Design Standards and Performance Measures[2]

This document was prepared for the BRT Major Investment Study as a part of the Wake Transit Plan. It envisions the features of BRT in Wake County and establishes a framework for future investment. Design standards establish the baseline for features that should be included in construction and operation of the BRT service, whereas performance measures report on the efficiency of that service. Both design standards and performance measures are important to ensure that the BRT service achieves the goal of providing "frequent, reliable urban mobility".

Two elements of the design standards that are relevant to the CAMPO RED lanes study are dedicated runningway and transit signal priority. This study identified dedicated runningway as a priority for delivery of reliable, high-frequency service in BRT operations. Therefore, the BRT infrastructure should include dedicated runningway in over 50 percent of the corridor. The type of runningway could closely resemble transit priority lanes. Transit signal priority (TSP) is another element of the BRT design that contributes to service reliability. The study recommends 100% of the signalized intersections on a BRT corridor be equipped with TSP technology; however, the level of implementation and combination of signal prioritization treatments can vary on an intersection-by-intersection basis, depending on traffic conditions and the expected impact TSP would have on alleviating delay.



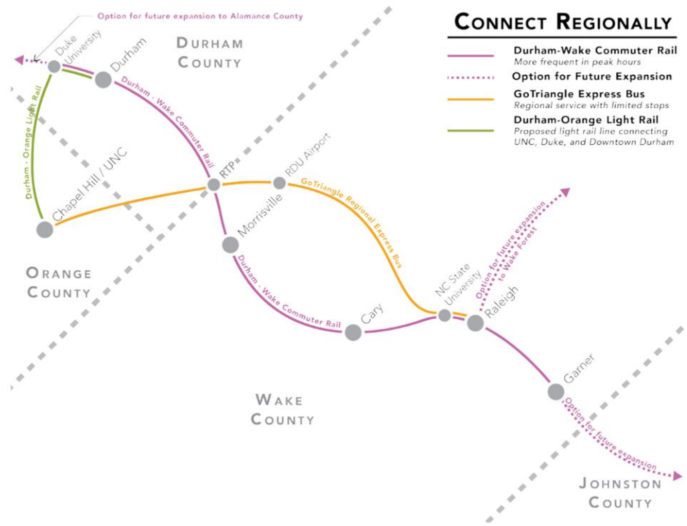
Source: AC Transit

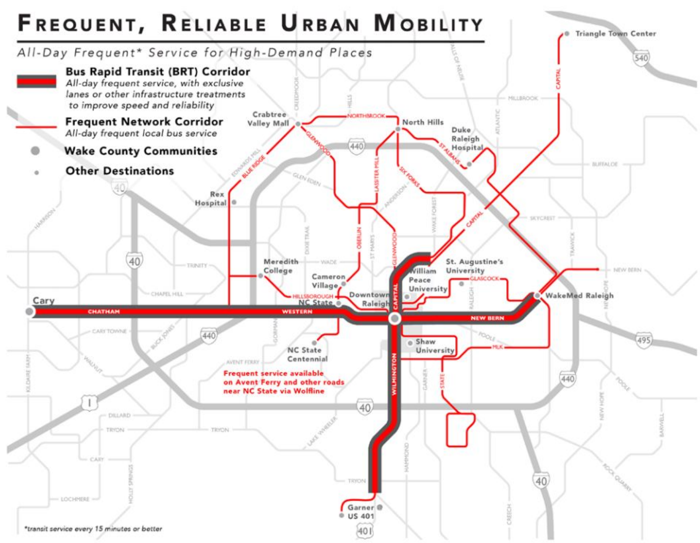
The study also recommends stop spacing standards of two stops per mile maximum in moderate-to-high density areas (10 or more jobs + population per acre) and one stop per mile maximum in low-density areas (less than 10 jobs + population per acre). It sets an on-time performance target of 85% of transit vehicles departing from stops less than one minute before and less than five minutes after the scheduled departure time. It targets a 16 miles-per-hour average operating speed for BRT service. These performance targets could shape expectations for the travel time and quality of service impacts associated with transit priority lanes.

[2] http://goforwardnc.org/wp-content/uploads/2018/11/Wake-MIS-BRT-Design-Standards-Performance-Measures-FINAL.pdf

WAKE COUNTY BRT DESIGN STANDARDS AND PERFORMANCE MEASURES		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	Minimum passenger boardings per revenue hour of operation: 25 (weekday service)
	Transit Mode Share	
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	Vehicle loading standards (number of riders on the bus relative to the seating capacity of the vehicle): • 120% in peak hours • 100% off-peak
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	On-time performance measured as the share of trips leaving -1 to +5 minutes of scheduled time. The target for this measure is 85%.
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	Minimum service frequency: 15 minutes (20 minutes in early morning/night/Saturday/Sunday service hours)
	Transit Signal Priority	TSP should be applied to 100% of intersections where it will provide a benefit to transit speed and/or reliability; queue jumps are appropriate where dedicated running way is not available
	Person/Vehicle Delay	
	Average Travel Speeds	Target: 16 mph. Stop spacing standards are key to maintaining target speed (2 stops/mile in moderate/high density areas, 1 stop/mile in low density areas)
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	
	Intersection Design	
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	

Wake Transit Plan[3]





The Wake County Transit Plan (WTP), adopted in November 2016, focuses on projects and investments needed to enhance transit travel throughout the county. The plan calls for more frequent bus service throughout a larger service area, operating for longer hours. The WTP highlights frequent and rapid bus service on major corridors to connect population and employment centers in the region. In general, the WTP targets service frequencies of 15-minutes or less for a network of key routes, supported by less frequent service on secondary routes to provide comprehensive coverage.

BRT provides frequent, high speed bus service, often in dedicated right-of-way or in transit priority lanes. The following BRT corridors are defined in the WTP:

1. Capital Boulevard
2. Wilmington Street
3. Western Boulevard/Chatham Street
4. New Bern Avenue

In addition to BRT infrastructure, the WTP calls for a frequent service network, on which buses would operate at 15-minute headways (or more frequently) all day. The proposed frequent service network includes the following major roads: Blue Ridge; Glenwood; Northbrook; Six Forks; St. Albans; Oberlin; Hillsborough; Martin Luther King, Jr.; State; Capital Boulevard; and Lassiter Mill.

For local fixed-route service, the Plan recommends enhanced service frequencies during peak commuting hours, extended service hours for most routes, and expanded service areas in both Raleigh and Cary. Finally, the plan establishes a Community Funding Area mechanism through which smaller municipalities that do not currently fund transit systems may establish local transit service, expanding system coverage over time.

Transit priority lanes are an appropriate strategy for achieving the rapid and frequent transit service network proposed by the WTP. Corridors identified in the WTP should be included for consideration as transit priority lane candidate corridors, and conditions along these corridors that impact transit travel speeds or reliability should be highlighted for potential resolution through transit priority lanes.

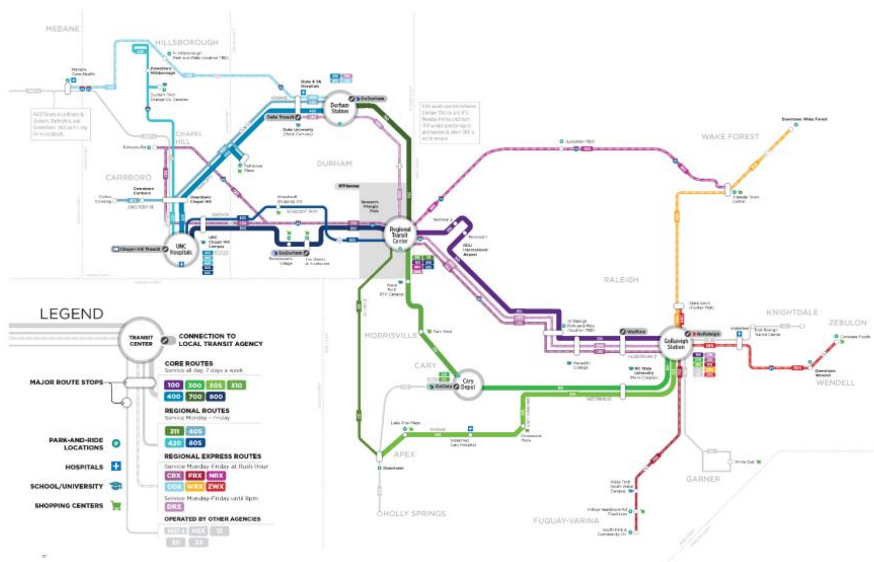
[3] http://goforwardnc.org/wp-content/uploads/2018/03/November-2016-Wake-Transit-Plan_small.pdf

WAKE TRANSIT PLAN		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	Central Raleigh accounts for the majority of high-ridership stops and corridors.
	Transit Mode Share	
	Traffic Volume	Forecasted (2040) traffic volumes indicate that many major roads will be above capacity. Transit investments like BRT and CRT are recommended as congestion mitigation tools/alternatives.
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	BRT improvements along several corridors will improve the speed, reliability, and amenities of bus services.
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	The existing frequent service network serves NCSU and central Raleigh, extending to Wake Forest and Knightdale. The frequent network (15 minutes or better all day) in Raleigh and Cary will increase from 17 miles to 83 miles
	Transit Signal Priority	Transit signal priority is planned along the following corridors: Western Boulevard between Raleigh and Cary; on or near Capital Boulevard between Peace Street and Wake Forest Road; New Bern Avenue between Raleigh Boulevard and WakeMed; along South Wilmington Street between Raleigh and Garner at US 401.
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	
	Accessibility	Plan seeks to maximize number of people and jobs near any all-day transit service and near Frequent Service Network.
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	
	Intersection Design	
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	

GoTriangle Short Range Transit Plan[4]

The GoTriangle Short-Range Transit Plan (SRTP) provides guidance for how the agency will develop and implement bus service through FY 2027. The Plan is oriented around three goals: (1) Make service faster and more time-competitive; (2) provide more frequent service; and (3) provide more all-day service. The components of the plan include an existing conditions and market analysis, a service analysis, a report on public involvement, and recommendations. The recommendations are derived from the existing conditions, market factors, and public input. Ultimately, the recommendations are focused on the broad goal of offering a regional network that meets current and future travelers' needs and maintains financial sustainability.

More specifically, the SRTP recommendations include service changes that help realize the plan goals. Key recommendations relevant to the CAMPO RED lanes study include:

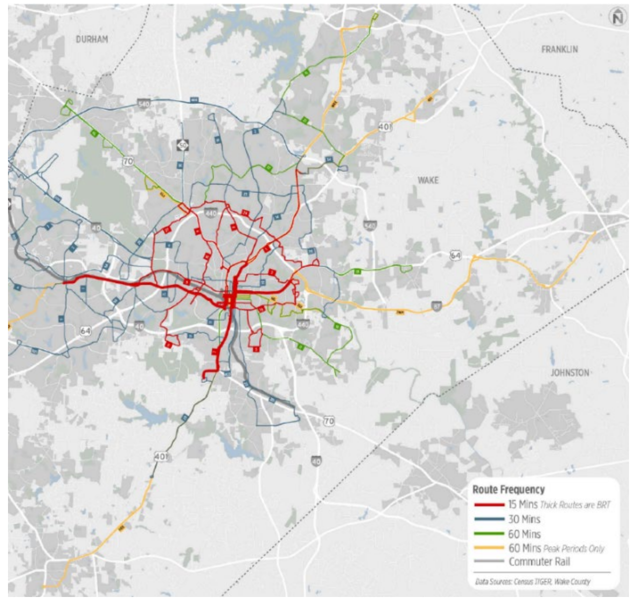


- Replace service between Cary and the RTC with new Route 310, providing service to Morrisville and Wake Tech RTP campus in western Wake County, and expand service to later operating hours and higher frequencies on weekends.
- Add service later at night and add more frequent service on weekends to Route 100.
- Add midday, night, and weekend service between Raleigh and Apex on Route 305. Convert Routes 102 (Garner-Raleigh) and KRX (Knightdale-Raleigh Express) to all-day services operated by GoRaleigh.
- Replace Route 201 with new Route NRX service along I-540 between Triangle Town Center and the RTC, and double frequency; also add park-and-ride capacity in the I-540 corridor to support ridership growth.
- Combine resources from Routes 105, 700, and DRX to provide all-day weekday express service between Duke/VA Hospitals, downtown Durham, NC State University, and downtown Raleigh. The route would add a stop at a relocated RTC but receive additional peak period trips and new, 30-minute midday service on weekdays.
- Route 300 Cary-Raleigh will be replaced by the Western Blvd BRT line.

[4] https://gotriangle.org/sites/default/files/att_a_gotriangle_short-range_transit_plan_final_nov_2018.pdf

GOTRIANGLE SHORT RANGE TRANSIT PLAN		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	Existing high ridership commuter routes include: 700 (Durham to RTC); 800 (RTC to UNC Hospital via Southpoint); 805 (RTC to UNC Hospital via Woodcroft); CRX (Chapel Hill to Raleigh); DRX (Durham to Raleigh). These routes generally utilize freeways such as I-40 or NC-147.
	Transit Mode Share	
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	The plan acknowledges limited commuter demand from Durham/Orange to Wake.
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	A goal of the plan is to make transit service faster and more time-competitive.
	Transit Service Frequency	A goal of the plan is to provide more frequent, all-day service.
	Transit Signal Priority	
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	
	Intersection Design	
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	

Wake Bus Plan[5]



The Wake Bus Plan was adopted in February 2019. It is a 10-year implementation plan focused on near-term transit capital and operational investments that support the fulfillment of the Wake Transit Plan (2016). The bus plan offers a year-by-year implementation plan and schedule for strategic investments that address the Wake Transit Plan's "Four Big Moves":

- **Connect regionally** – Connect major destinations throughout the Triangle region with reliable transit, such as commuter rail and express bus.
- **Connect all Wake County Communities** – Connect municipalities throughout Wake County as well as RDU and RTP using regional and express bus.
- **Frequent, Reliable Urban Mobilit**y – Develop frequent service in the county's urban core, including BRT and high frequency fixed route bus service.
- **Enhanced access to transit** – Make services more convenient, extend operating hours, and ensure the bus is fast, reliable, and comfortable.

The plan focuses on bus service rather than other potential major investments like BRT and commuter rail. A schedule of capital and operating investments is laid out for growing the region's bus system and serves as a guide for programming specific investments through annual Wake Transit Work Plans.

There are 10 frequent service routes identified in the plan, offering headways of 15-minutes or shorter and operate for 18 hours a day. They are focused in county's densest corridors. Additionally, an increase in local fixed route bus service is envisioned. These routes will operate at 30-minute headways for most of the day and service will be available for 18 hours a day. Community routes operate at one-hour headways up to 14 hours per day, serving lower density areas and connecting to the system's more regular services. Finally, express routes operate during peak periods and provide regional connections with minimal stops to maintain competitive travel times.

The plan anticipates significant increases in transit funding from various sources over its 10-year horizon. Overall, the existing system that offers 300,000 annual hours of bus service will be expanded to offer 800,000 annual hours of service by 2027. Spending on Wake County bus service will grow from $30 million today to roughly $85 million in the same timeframe. These investments and service increases will equip transit providers in the region to shift from service models focused on coverage (with low levels of service) to an emphasis on ridership.

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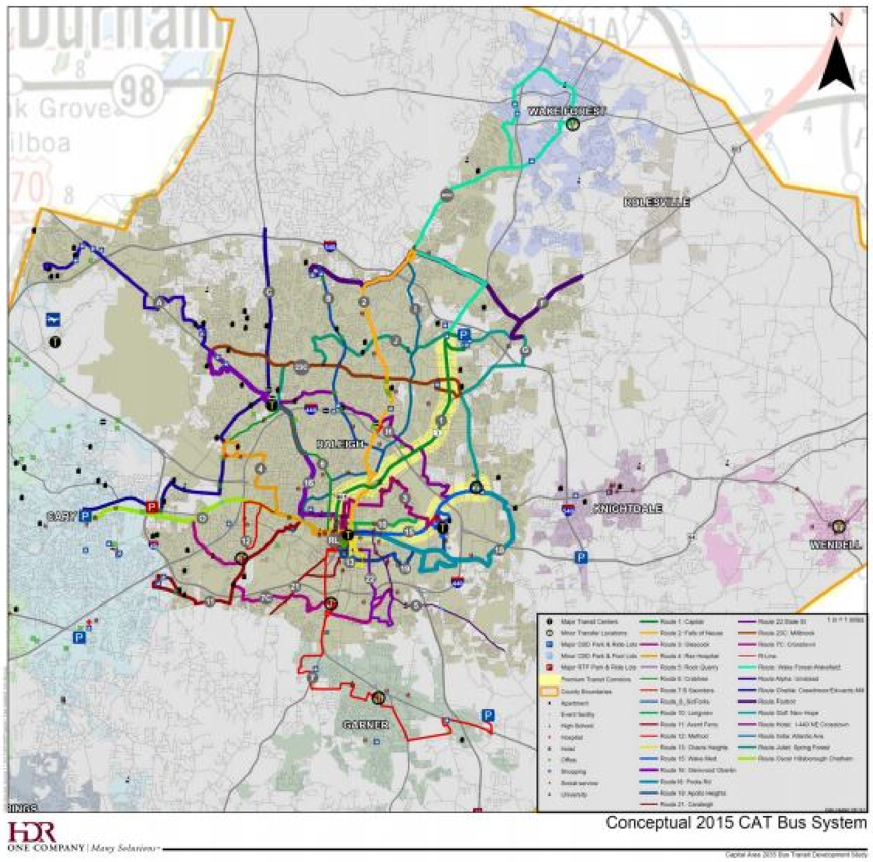
[5] http://files.www.campo-nc.us/about-us/committees/wake-county-transit-planning-advisory-committee-tpac/document-library/Wake_Transit_10-Year_Bus_Plan_final.pdf The Wake Bus Plan includes the most recent Short Range Transit Plans (Proposed Transit Service Projects and Changes) for GoRaleigh, GoCary, and GoTriangle.

WAKE BUS PLAN		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	Devote increasing investment toward ridership-oriented services (frequent service, e.g.). • 2018 – 26% ridership/74% coverage • 2024- 54% ridership/46% coverage • 2027 – 66% ridership/34% coverage • Target – 75% ridership/25% coverage
	Transit Mode Share	
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	Increase access to frequent service (15-minute max. headways) throughout the region by developing/funding more high-frequency routes.
	Transit Signal Priority	
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	Enhance service frequency and reliability in the county's urban core and densest corridors.
	Parking/Curb space	
	Accessibility	Steadily increase the number of jobs and residents within walking distance (¾-mile) of high-frequency transit
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	
	Intersection Design	
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	

GoRaleigh/Capital Area Transit (CAT) 2012 Short Range Transit Plan[6]

The City of Raleigh/Capital Area Transit (CAT) Short Range Transit Plan adopted in 2012 sets forward recommendations in a three to five-year timeframe. The aim of the plan is to initiate implementation of the long-range transit plans developed for Wake County. The plan is formulated around the following goals: (1) develop an enhanced, expanded bus system; and (2) introduce a long-range rail transit system. Any actions to realize these goals should satisfy the following objectives: (1) improve mobility; (2) increase regional connectivity; (3) create new employment opportunities; and (4) reduce the impact of congestion.



Conceptual 2015 CAT Bus System

More specifically, to create the envisioned enhanced bus service network, service changes should enhance existing corridors. One particular service change that achieves this is the establishment of "Premium Transit Corridors", corridors that have high ridership, potential for growth, and demand for high frequency transit service. Premium Transit Corridors will offer all-day service at frequencies of every 15 minutes during the weekday peak period and 30 minutes off peak and on weekends. The corridors designated "premium" are: Capital Boulevard; New Bern Avenue; Rock Quarry Road; South Saunders Street; Avent Ferry Road; Hillsborough Street; Glenwood Avenue/Oberlin Road; Six Forks Road; and Falls of Neuse Road.

Overall, the SRTP set performance measures for ridership levels and annual hours of service. For regular routes, targeted passengers per revenue hour (p/h) is 25 for weekdays, 20 for Saturdays, and 15 for Sundays. This measure was developed based on current performance levels and projected network development. The annual hours of service are anticipated to increase significantly in the 5-year planning period, approximately 77%. This could translate to an increase in ridership of 4 million annual riders, reaching approximately 9.2 million riders annually in 2016.

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[6] https://www.raleighnc.gov/services/content/PWksTransit/Articles/ShortRangeTransitPlan.html

GORALEIGH/CAPITAL AREA TRANSIT 2012 SHORT RANGE TRANSIT PLAN		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	Existing high-ridership routes include: Route 15 (WakeMed); Route 1 (Capital); Route 7 (South Saunders); Route 4 (Rex Hospital); Route 2 (Falls of Neuse) Performance target of 25 passengers per hour on local weekday routes.
	Transit Mode Share	
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	Target maximum headway of 30 minutes on all routes throughout the 14-hour weekday span of service. Establish premium transit corridors with service headways of 15-minutes or shorter during peak periods.
	Transit Signal Priority	Signal timing and queue jumper lanes at intersections recommended for the New Bern Avenue and Capital Boulevard Premium Transit Corridors.
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	
	Parking/Curb space	
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	
	Intersection Design	
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	The cost for premium transit corridor improvements on New Bern Avenue is estimated at $2.43 million. The cost for improvements on Capital Boulevard is estimated at $4.6 million.

Capital Area Bus Transit Development Plan (TDP)

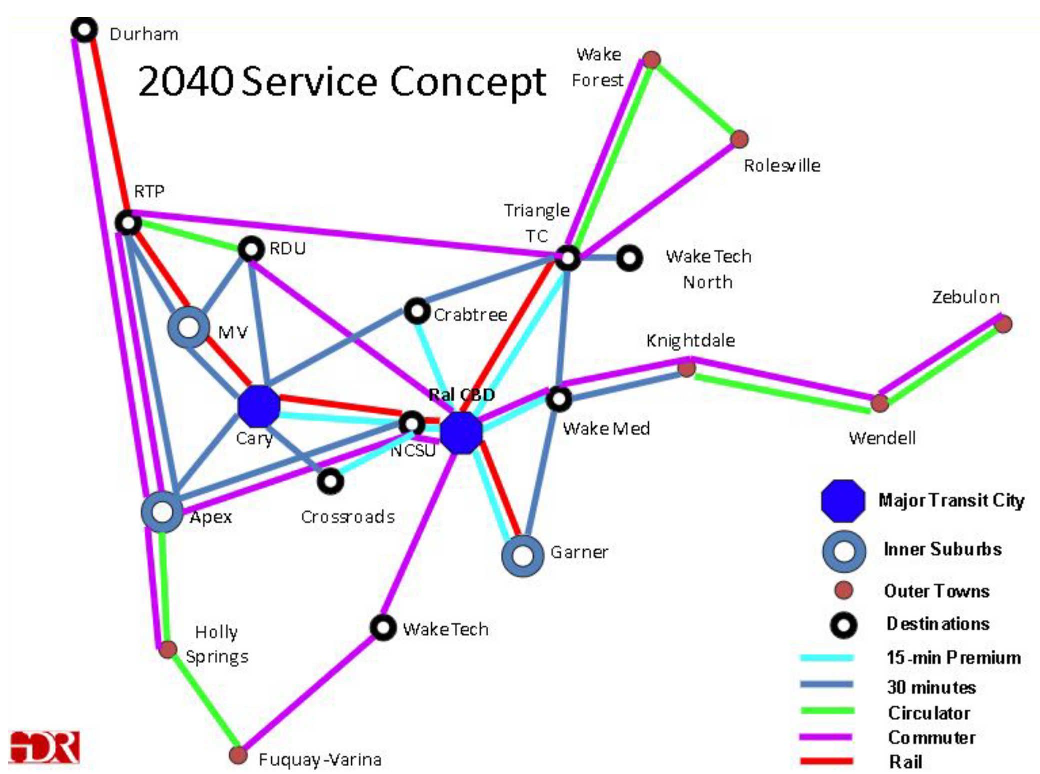
The Capital Area Bus Transit Development Plan (TDP) was published in 2011 and has a planning horizon of 2040. The Plan offers a framework for transit service and capital improvements to improve mobility in the CAMPO region. The Plan examines existing conditions and forecasted growth and makes financially-feasible recommendations for transit service and capital improvements. One of the key recommendations of this TDP is an enhanced bus system that improves mobility, connects the region, and reduces vehicular traffic. An element of the recommended enhancements to existing transit service that is relevant to the CAMPO RED lanes study is the establishment of Premium Transit Corridors and Commuter Corridors. Premium Transit Corridors serve local bus routes and offer pedestrian and transit facilities. Commuter Corridors permit bus on shoulder operations and signal prioritization. These corridors may be strong candidates for future RED lane implementations.

<u>Premium Transit Corridors</u>

1. Avent Ferry
2. Capital
3. Hillsborough/Chatham
4. Crabtree
5. Falls of Neuse
6. New Bern
7. Rock Quarry
8. Saunders
9. Six Forks

<u>Commuter Corridors</u>

1. I-40 West
2. I-40 East
3. US 1 North – Capital
4. US 401 South
5. US 64 East
6. US 1 South
7. Creedmoor/Glenwood



CAPITAL AREA BUS TRANSIT DEVELOPMENT PLAN		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	Existing high-ridership routes include: Route 15 (WakeMed); Route 1 (Capital); Route 7 (South Saunders); Route 4 (Rex Hospital); Route 2 (Falls of Neuse) Performance target of 25 passengers/hour for local fixed route weekday service
	Transit Mode Share	
	Traffic Volume	Forecast (2035) traffic volumes indicate the following desired travel patterns: Apex-Holly Springs-Fuquay-Varina; Apex-Cary; Cary-Morrisville; RDU Airport-North Raleigh; and Wake Forest-North Raleigh.
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	• 30 minutes (local routes, weekdays) • 15 minutes (commuter routes, weekday peak) • 30 minutes (neighborhood circulators, weekday peak) • 10 minutes (activity center special circulators) • 15 minutes (peak)/30 minutes (off-peak) on premium transit corridors
	Transit Signal Priority	
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	Transit-supportive density identified as 7,500 "persons" (i.e., jobs plus residential population) per square mile
	Context Classification/ Complete Streets	
	Parking/Curb space	
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	
	Intersection Design	
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	

2045 Metropolitan Transportation Plan[7]

The 2045 MTP is a joint planning effort of the Capital Area Metropolitan Planning Organization (CAMPO) and the Durham-Chapel Hill-Carrboro Metropolitan Planning Organization (DCHC MPO). This plan was approved in 2018 to guide future investment in roads, transit service, and bicycle and pedestrian facilities in the Triangle region. Focusing on the intersections between land development and transportation investment, the plan is organized around three planning focal points: (1) transit station area development; (2) access management for major roads; and (3) context-sensitive complete streets, serving the needs of all users.

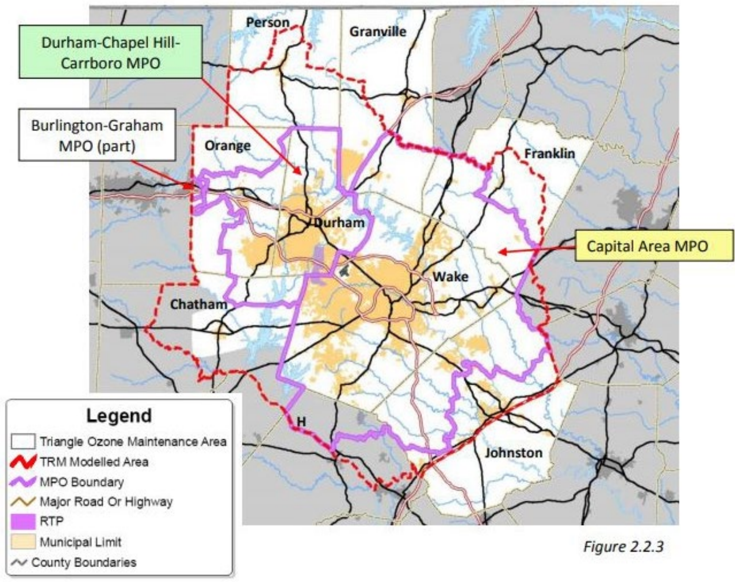


Figure 2.2.3

The transportation investments recommended in the MTP are typical of most long-range transportation plans, highlighting projects to build new roads and widen existing ones, strategically invest in increased local and regional transit facilities and services, and maximize the effectiveness of existing transportation capacity, usually through the use of technology, transportation demand management strategies, and operational enhancements to key corridors that improve safety and traffic flow without adding capacity.

The plan also suggests a key role for bus rapid transit (BRT) in meeting the region's future travel demand:

- A BRT system connecting Raleigh, Cary, Morrisville, Research Triangle Park, and Garner;
- Development of dedicated fixed guideway for the initial BRT corridors in Wake County (see Wake Transit Plan below);
- The addition of BRT service to Midtown Raleigh;
- An extension of dedicated fixed guideway and BRT service to New Hope Rd. along the New Bern BRT corridor in Raleigh; and
- A north-south BRT corridor in Cary along the Harrison-Kildaire Farm-Tryon Rd. corridor.

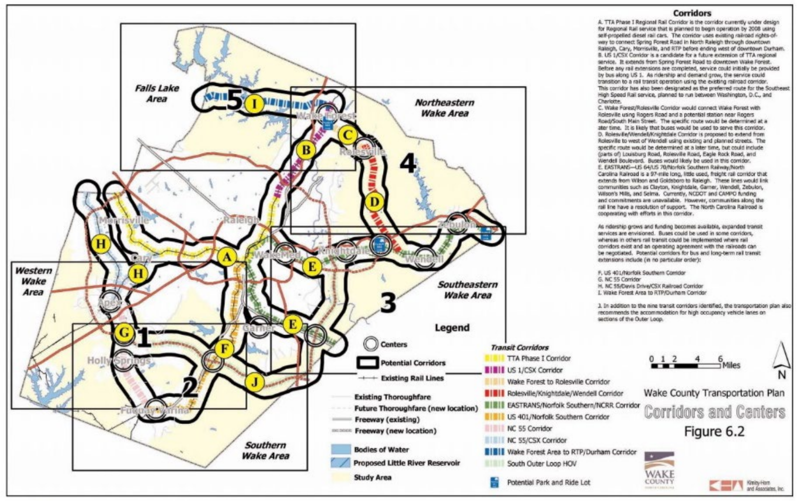
In addition to identifying several potential BRT corridors and others potentially suited for transit priority lanes, the MTP's emphasis on multimodal solutions, access management, and complete streets suggests that transit priority lanes should be considered on all major roadways, acknowledging access needs and sharing space with other modes as much as feasible. RED lanes, as a strategy, fit with highway capacity, transit capacity, and multimodal operational approaches to addressing transportation issues.

[7] http://files.www.campo-nc.us/transportation-plan/2045-metropolitan-transportation-plan/Final_Report/2045_Joint_MTP_Adopted_Chap1-10_combined.pdf

2045 METROPOLITAN TRANSPORTATION PLAN		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	The plan acknowledges an increased emphasis on transit for regional mobility, connecting regional centers, and offering reliable service in urban corridors.
	Transit Mode Share	
	Traffic Volume	The regional emphasis on highway capacity and performance remains strong, and numerous highway capacity projects are planned to address expected increases in travel demand and traffic volume.
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	Grow the county's frequent bus network from 17 miles in 2016 to 83 miles by 2027. Frequent service is defined as 15-minute or shorter headways.
	Transit Signal Priority	Not specifically mentioned, but technology-based system enhancements and management approaches are highlighted as strategies to enhance operations and safety. These could include TSP.
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	The MTP aligns planned transportation investments with supportive land development patterns. Transit-oriented development is a key focus of the plan.
	Context Classification/ Complete Streets	The future transportation system will provide greater transportation choices and evolve to suit changing needs and travel preferences. This is highlighted by the plan's emphasis on "safe and healthy" streets accommodating a full range of users.
	Parking/Curb space	
	Accessibility	Noted emphasis on first/last-mile access to transit.
	Facility Functional/Access Class	Roadway access management is a key focus of the plan.
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	
	Lane Width	
	Intersection Design	
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	

Wake County Comprehensive Transportation Plan[8]

The 2003 Wake County Transportation Plan addresses mobility needs in unincorporated areas of Wake County. Initially envisioned as a collector street plan, the study expanded to encompass thoroughfares, public transit, bicycle, and pedestrian needs. The comp plan builds on the 2025 CAMPO Plan that was adopted in 2002. The comp plan identifies safety and roadway capacity improvements and defines concepts for new roadway corridors. Many corridors in the County experience high daily traffic volumes and/or are heavily congested. This plan anticipates future traffic growth by recommending road widening projects on key major thoroughfares. The plan also establishes ten "priority transit corridors"; major transit routes should be planned around these corridors to connect activity centers. These priority transit corridors are listed below:



1. TTA Phase I Regional Rail Corridor – connects Spring Forest Road in North Raleigh through downtown Raleigh, Cary, Morrisville, and RTP before ending west of downtown Durham
2. US 1/CSX corridor – Extends from Spring Forest Road to downtown Wake Forest
3. Wake Forest/Rolesville corridor - connects Wake Forest and Rolesville using Rogers Road
4. Rolesville/Wendell/Knightdale corridor - aligned with Louisburg Road, Rolesville Road, and Eagle Rock Road
5. EASTRANS-US 64/US 70/Norfolk Southern Railway/North Carolina Railroad
6. US 401/Norfolk Southern Corridor
7. NC 55 Corridor
8. NC 55/Davis Drive/CSX Railroad Corridor
9. Apex to Cary corridor
10. Wake Forest/Rolesville area to RTP and Durham

In addition to regional transit service, the plan recommends other transit-supportive improvements, such as Park and Ride locations in Wake Forest and at the US 64 Bypass Interchange. Other relevant elements of the plan are traffic management solutions for regional connections, particularly HOV lanes on the Outer Loop between NC 55 in Holly Springs and US 401 South.

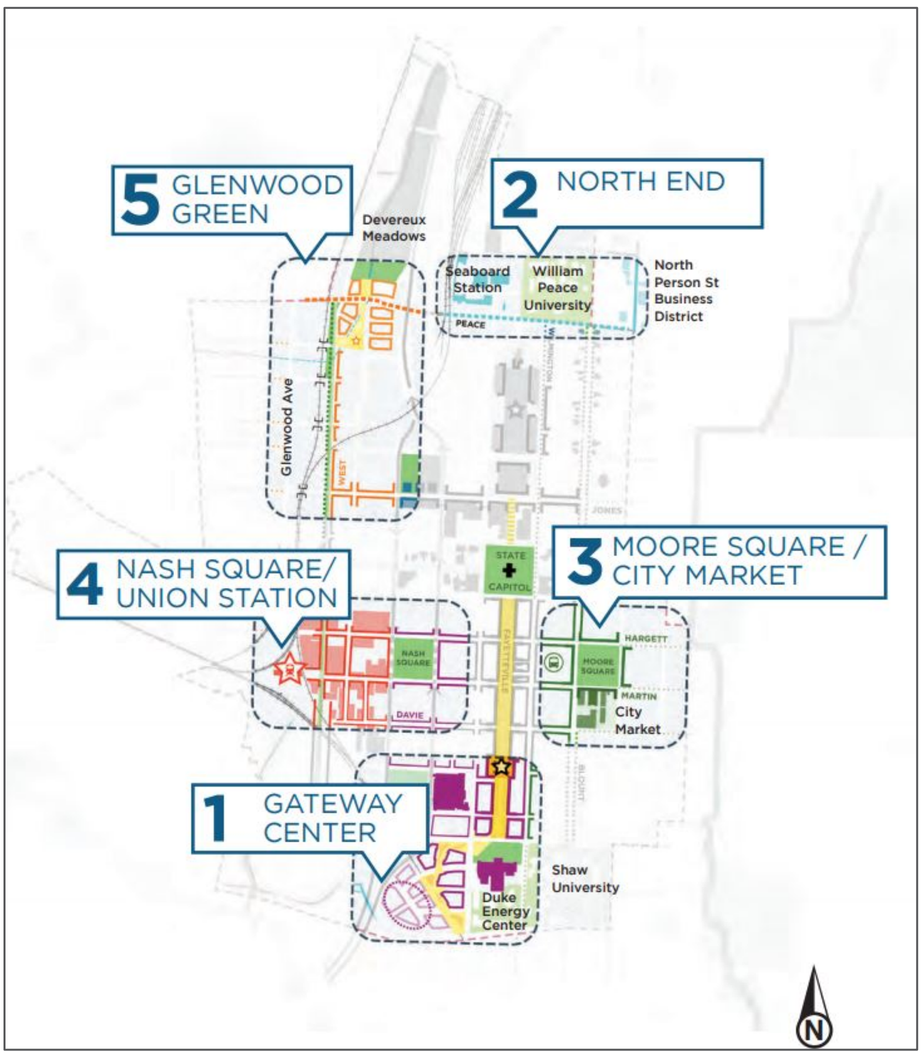
[8] http://www.wakegov.com/planning/transport/Documents/Wake%20County%20Transportation%20Plan.pdf

WAKE COUNTY COMPREHENSIVE TRANSPORTATION PLAN		
Topic Area	**Indicator**	**Findings**
Demand *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit Ridership	Existing (2002) CAT service carries 10,000 weekday riders. Existing (2002) TTA service carries 2,550 weekday riders.
	Transit Mode Share	
	Traffic Volume	The most heavily congested major thoroughfares include sections of US 1 (Capital Boulevard), US 70, US 64, and NC 55. Falls of the Neuse Road, Holly Springs Road, Ten Ten Road, and US 401 (north) also experience heavy traffic and long delays in peak hours.
	Non-Motorized Users	
	Person Throughput	
Operations *(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)*	Transit On-Time Performance	
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	
	Transit Signal Priority	
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts *(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)*	Adjacent Land Uses	
	Context Classification/ Complete Streets	This plan recommends that all thoroughfares, connectors and collectors have a sidewalk on at least one side of the street. It is acknowledged that this is a long-term goal (100 year horizon) and unlikely to be realized in the planning horizon for this plan.
	Parking/Curb space	
	Accessibility	
	Facility Functional/Access Class	
Design *(Available ROW, shared modes/ movements)*	Number of Lanes	The plan recommends high occupancy vehicle lanes on sections of the Outer Loop between NC 55 in Holly Springs and US 401 South. Widening improvements are recommended on several key corridors in the study area to accommodate future traffic volumes. These improvements often include the addition of medians, turn lanes, and wide outside lanes.
	Lane Width	
	Intersection Design	
Other	Safety	
	Enforcement	
	Maintenance	
	Cost	Transit expansions were estimated to cost $750 million.

Complementary Plans and Studies

City of Raleigh Downtown Plan[9]

The Downtown Plan was adopted in 2015 and lays out goals and action items to realize a vision for downtown Raleigh for the next 10 years. The plan is framed by four themes: Breathe, Move, Stay and Link. Move – or making walking, biking, and transit the preferred ways to get in and around downtown Raleigh - supports the goal of greater sustainability and emphasizes transportation access. Goal 3 of Move, "Enhance transit accessibility in downtown through service improvements", is aligned with the aim of this RED Lanes study. In particular, Action 21 to "Conduct a follow-up study to the 2015 Wake County Transit Investment Strategy that refines and finalizes transit operation and infrastructure investment details in downtown Raleigh" is currently underway and includes improvements such as route consolidation and increased frequency. The strategy to realize this action is represented by the Phase II of the Raleigh Union Station, which would support high frequency bus service within downtown and throughout the region. Finally, the plan focuses on several catalyst areas that are the centers of growth and activity in downtown Raleigh. Two catalyst areas – Moore Square and Nash Square/Raleigh Union Station – emphasize transit as a part of their development.



9 https://www.raleighnc.gov/business/content/PlanDev/Articles/UrbanDesign/DowntownPlan.html

NEW BERN AVENUE CORRIDOR STUDY[10]

The New Bern Avenue Corridor Study, approved in 2012 by the Raleigh City Council, is the collaborative effort of City of Raleigh, community members, property owners, businesses, and other stakeholders. New Bern Avenue is a corridor of historic significant to the City of Raleigh, traversing east from downtown Raleigh to Wake Medical Center. One of the City's most heavily used transit corridors, New Bern Avenue required an upgrade to efficiently serve its role in the transportation network.

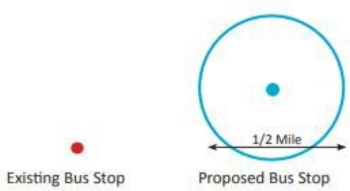
The goals of the study include: (1) improve the aesthetic and appearance of the corridor; (2) encourage non-auto travel along the corridor; and (3) stimulate economic activity in the corridor area. The recommended improvements renew New Bern Avenue as a symbolic and literal gateway to Raleigh and improve the safety and mobility of travelers through the corridor. The improvements that are relevant to the CAMPO RED lanes study include streetscape design and transit patterns. In particular, the plan recommends supporting transit use by implementing a complete streets design approach, as well as reducing bus headways to 15 minutes all day and upgrading passenger amenities.

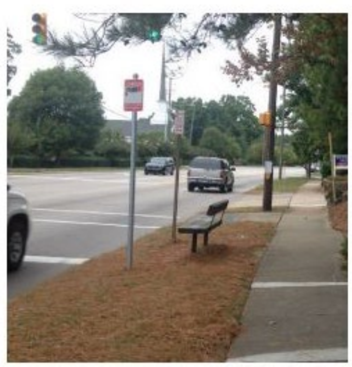
[10] https://www.raleighnc.gov/business/content/PlanDev/Articles/UrbanDesign/NewBernAvenueCorridorStudy.html

Six Forks Road Corridor Study

The Six Forks Road Corridor Study, adopted in 2018, is the outcome of a multi-year collaborative planning effort that engaged city staff, consultant team, citizens, stakeholders, community leaders, residents, and businesses to create a shared vision for the Six Forks Road corridor. This vision is "to enhance the Six Forks Road corridor in a way that defines a unique sense of place with enhanced fluidity of movement, environmental sensitivity, and connectivity for residents, workers, students, and visitors using transportation modes of all types, including cars, bikes, pedestrian, and public transit."

In particular, key stakeholders are interested in transforming Six Forks Road into a high priority transit corridor that allows for future high quality transit service, such as bus rapid transit. To realize that future vision, near term actions will include simplifying and consolidating bus stop locations to promote ridership and facilitate higher frequency service. The plan recommends high quality, high amenity bus stops be spaced at half-mile intervals along the corridor – allowing transit riders access to a bus shelter within a quarter-mile radius, generally. Finally, the provision of dedicated transit lanes, queue jumps, and signal prioritization are recommended as a strategy for future transit service.





Example of Existing Conditions

Example of Proposed Condition

BLOUNT ST – PERSON ST CORRIDOR STUDY

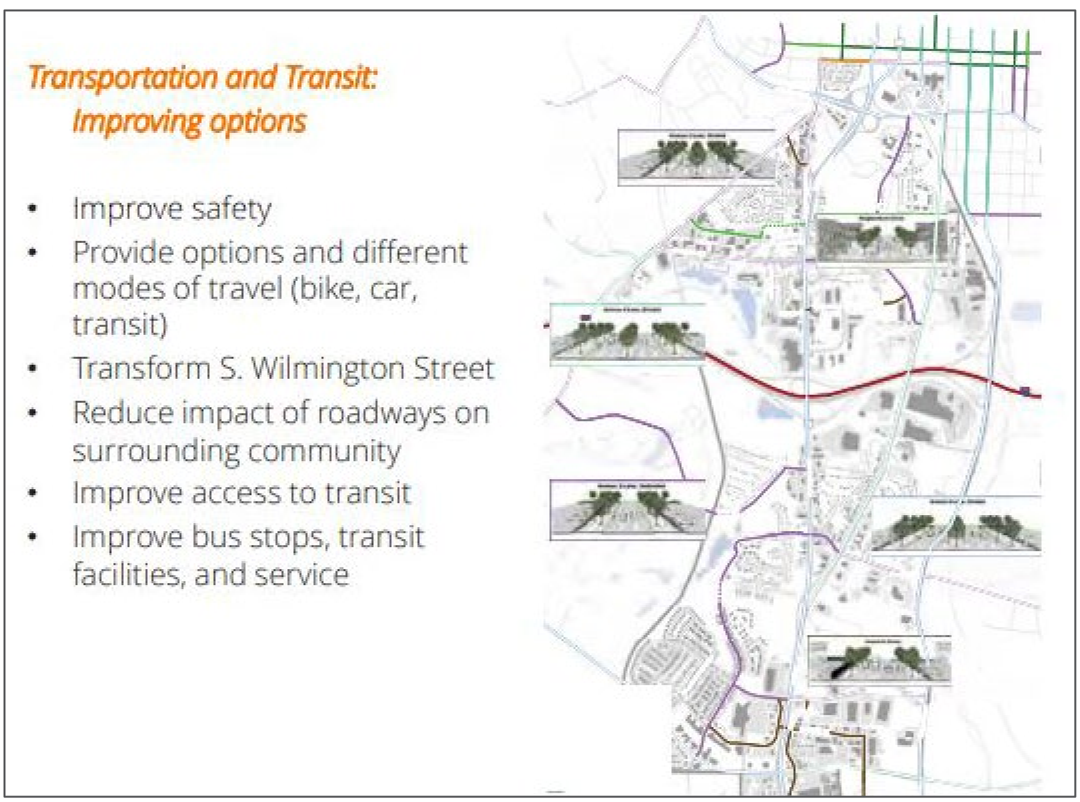
In 2013, the Raleigh City Council approved the Blount Street/Person Street Corridor Plan. The study corridor extends more than five miles from Capital Boulevard to I-40 and includes Wake Forest Road and Hammond Road. The core of the corridor is the Blount Street/Person Street one-way couplet.

The plan uses a phased approach to create a corridor that is safe and attractive to all users. The corridor is a critical access point to Downtown Raleigh, surrounding neighborhoods and regional destinations. The speed and behavior of vehicular traffic should be managed, and the plan aims to address this need. The plan provides examples of multiple road reconfigurations and ultimately recommends a multi-part, three-phase approach that will improve the pedestrian experience, calm traffic, and improve landscaping/aesthetics. In addition to the vehicular and pedestrian modes, Blount and Person Streets are a key transit corridor. Therefore, the proposed street design balances pedestrian and vehicular mobility with transit needs.

Southern Gateway Study

The Southern Gateway Study, adopted in 2017, focuses on South Saunders and South Wilmington Streets, which form the southern gateway to Downtown Raleigh. These roads are major corridors that connect surrounding areas to downtown and I-40. The first phase of the project identified the issues in the planning area and defined a vision for South Saunders and South Wilmington Streets. The second phase formed design ideas and developed an implementation plan. Finally, the final report and corresponding comprehensive plan amendments were submitted and approved by Raleigh City Council and the Planning Commission. A key theme of this study is to improve safety for all users, to provide transportation options, and identify places with excess capacity to improve options for multimodal mobility. Thus, the major recommendation of this study is to transition South Wilmington Street into a complete street, with two vehicular travel lanes, a separate bike facility, and dedicated transit lanes in preparation for bus rapid transit. Other recommendations of this study include:

- Improve key intersections along S. Saunders Street to address bike/pedestrian safety and access to transit.
- Improve and augment east-west road connections to link neighborhoods to each other and to the redesigned S. Wilmington Street.
- Evaluate the district's connection to the southern edge of downtown by urbanizing the interchanges along MLK Boulevard and by providing a better bike / pedestrian connection to downtown (at Fayetteville Street).
- Transform the S. Wilmington Street flyover to accommodate transit connections south to Tryon Road.
- Establish Lake Wheeler Road as a bike / pedestrian corridor.



Cameron Village Hillsborough Street Small Area Plan[11]

The Cameron Village Hillsborough Street Small Area Plan was adopted in 2017. The plan includes a community vision that prioritizes conservation of historic neighborhoods, offers guidance for new development, and recommends investment for multimodal mobility.

The recommendations of this plan are centered around seven planning strategies: (1) complete pedestrian and bicycle networks; (2) improve and expand parks and open space; (3) increase transit options; (4) distribute and calm traffic; (5) plan for adequate and accessible parking; (6) zone for the future; and (7) promote quality design. Public input collected as a part of this planning process ranked "high frequency bus service and transit stops" as a high priority. With regards to improving transit options, the following recommendations were provided:

FIGURE 28. TRANSIT IMPROVEMENTS PROPOSED FOR THE CAMERON VILLAGE STUDY AREA

1. Continue to improve coordination between systems
2. Consolidation and improvement to some stops
3. Continue to strategically increase frequency
4. Continue to utilize technological improvements, such as signal prioritization
5. Work with employers and groups of employers to increase transit use
6. Implement the Wake County Transit Plan recommendations for the area

[11] https://www.raleighnc.gov/business/content/PlanDev/Articles/UrbanDesign/CameronHillsborough.html

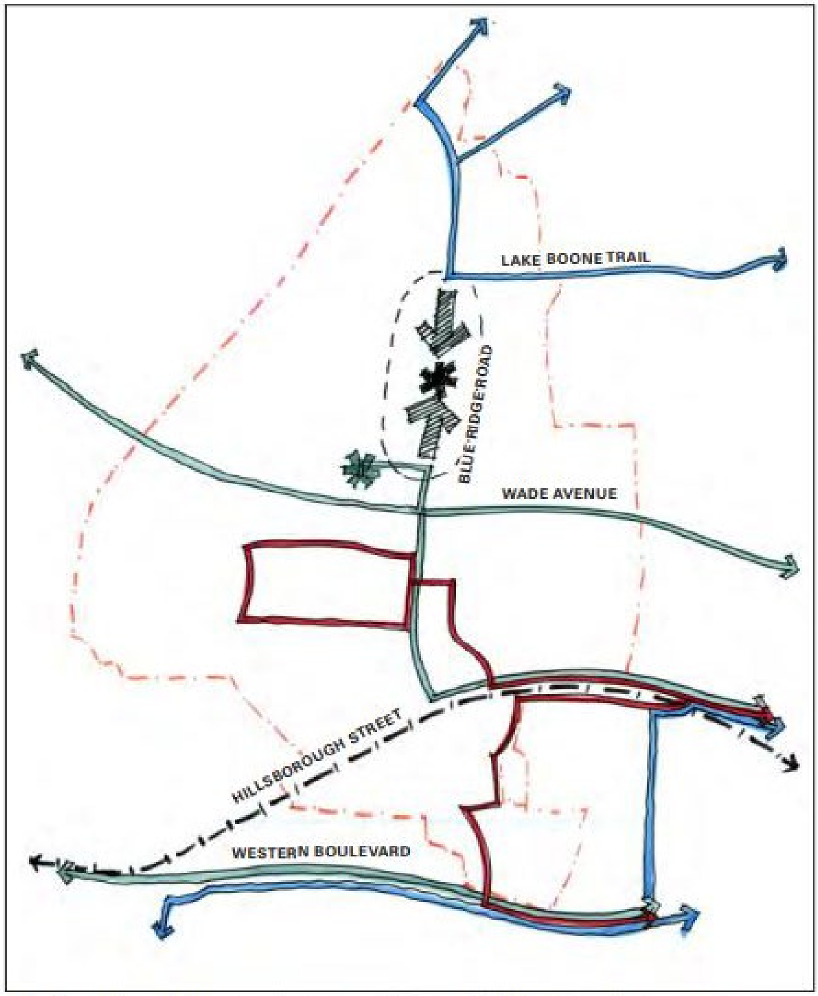
Jones Franklin Area Study

The Jones Franklin Area Study was adopted in 2011 by Raleigh City Council. The study explores the area near the intersections of Jones Franklin Road, Western Boulevard and Hillsborough Street. More specifically, the study explores transportation and land uses in the area and offers recommendations to guide future development, including a land use classification for the Future Land Use Map. The results of the study fall into three categories:

1. Authorize a Comprehensive Plan amendment to the future land use map and the thoroughfare upgrades map with the recommended land use and street classification found in this study.
2. Use the recommendations in this study to inform the application of form-based, mixed-use districts that will be applied to this area during the new development code process.
3. Focus on creating a strong multi-modal transit hub. This district is situated at the nexus of several transit routes, and infrastructure improvements should be prioritized to strengthen the district's connectivity.

Specific transportation infrastructure recommendations are provided as a part of this study. These include: (1) improving and coordinating transit facilities; and (2) consolidating bus services through shared facilities.

BLUE RIDGE ROAD DISTRICT STUDY



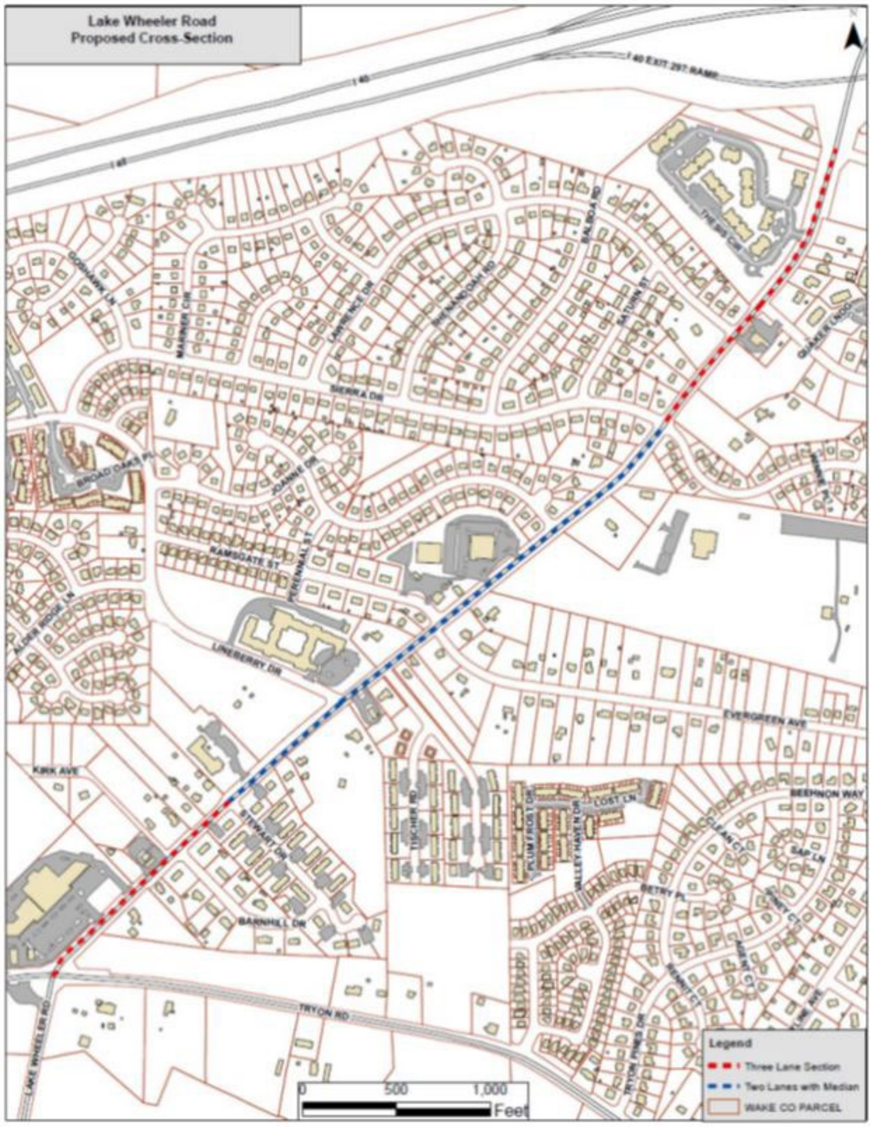
The above diagram illustrates existing transit lines, and highlights the existing transit gap between Lake Boone Trail and Wade Avenue.

The Blue Ridge Road District Study was adopted in 2012 and addresses a two-mile stretch of Blue Ridge Road in Raleigh, surrounded by some of the city's most attractive destinations: the North Carolina Museum of Art, PNC Arena, Carter-Finley Stadium, and the North Carolina State Fairgrounds. While Blue Ridge Road is an important destination, the area is not well-suited to support the visitor traffic, due to its limited connector road network, a lack of amenities, and lack of economic development. This study aimed to provide guidance for future development within a newly defined Blue Ridge Road District to be implemented over time. The goal of this study is to establish a "sense of place" in the Blue Ridge Road District. This study was conducted utilizing stakeholder feedback to develop a shared vision for the future of the Blue Ridge Road District. This vision can be delineated into three elements: Transportation, Green Infrastructure, and Development. Within the Transportation element, the following actions were recommended:

- Blue Ridge Road to serve as a pilot project for NCDOT Complete Streets program
- Support the planned extension of the Wake County Transit Plan's Creedmoor Road/PNC Service
- Recommend a bus line that serves Blue Ridge Road District at 10-minute frequency, connecting Crabtree Valley Mall to Western Boulevard
- Connect the District to regional light rail transit

Lake Wheeler Road Corridor Study

Adopted in 2013, this study examines a 1.3-mile portion of Lake Wheeler Road between I-40 and Tryon Road. The recommended improvements and overall strategy developed for this corridor are reflective of the community's desire to expand multimodal travel options on Lake Wheeler Road to include pedestrians, cyclists and transit users.



The final recommendation for this corridor is a three-lane and two-lane median divided cross section, representative of a context-appropriate roadway design. This is a complete streets design, including sidewalks and bicycle lanes on both sides. The aim of this approach is to improve safety, reduce congestion, and improve transit access in the corridor. Existing transit service is provided by GoRaleigh and operates at transit stops located near Sierra Drive, Lineberry Drive and the Raleigh Oaks Shopping Center. While this study does not recommend expanded bus service, it is aligned with the Wake County Transit Plan to provide 30-minute frequency peak hour service on Lake Wheeler Road from Tryon Road to downtown Raleigh.

Western Boulevard Crossing Study[12]

The Western Boulevard Crossing Study, published in 2013, was initiated by CAMPO to examine and improve the infrastructure and safety for all modes of travel in this major corridor in Raleigh. The corridor – approximately one-mile long – carries over 30,000 vehicles per day and hosts hundreds of crossings at various locations. The purpose of this study was to craft a solution for a safe crossing for cyclists, pedestrians, and transit vehicles, as well as to create a complete streets environment throughout the corridor. Specifically, bicycle, pedestrian and transit movements over or under the boulevard, or an additional interchange, were analyzed. Special attention was paid to the Avent Ferry Road intersection, since there is high transit demand and a high level of pedestrian crossings. The Plan offers three options for the improvement. Two of the options incorporate transit service – a bicycle, pedestrian, and transit tunnel or a full interchange. Based on qualitative and quantitative analysis, the recommended option is a bicycle and pedestrian only tunnel at the Avent Ferry Road intersection. This solution will leave buses and other motorized vehicles navigating the intersection at-grade. However, this solution could simplify the implementation of transit priority lanes by reducing potential conflicts between transit vehicles and non-motorized users.

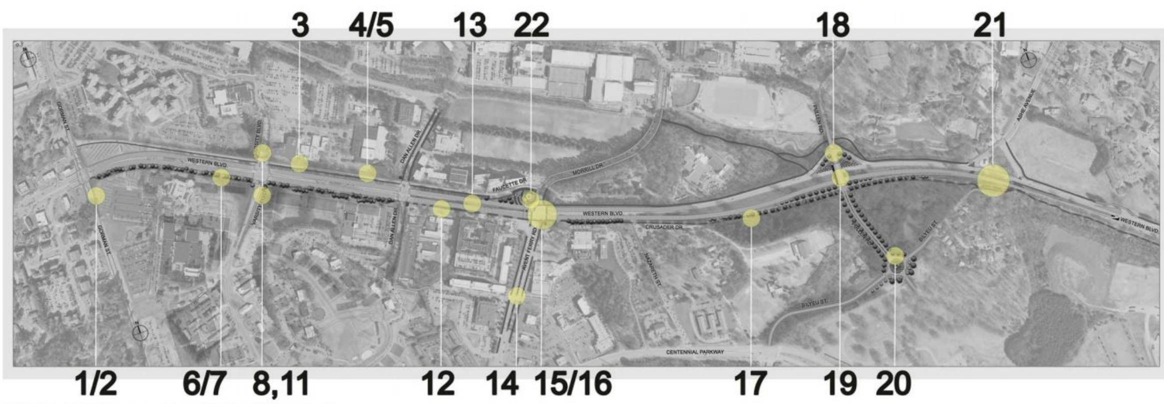


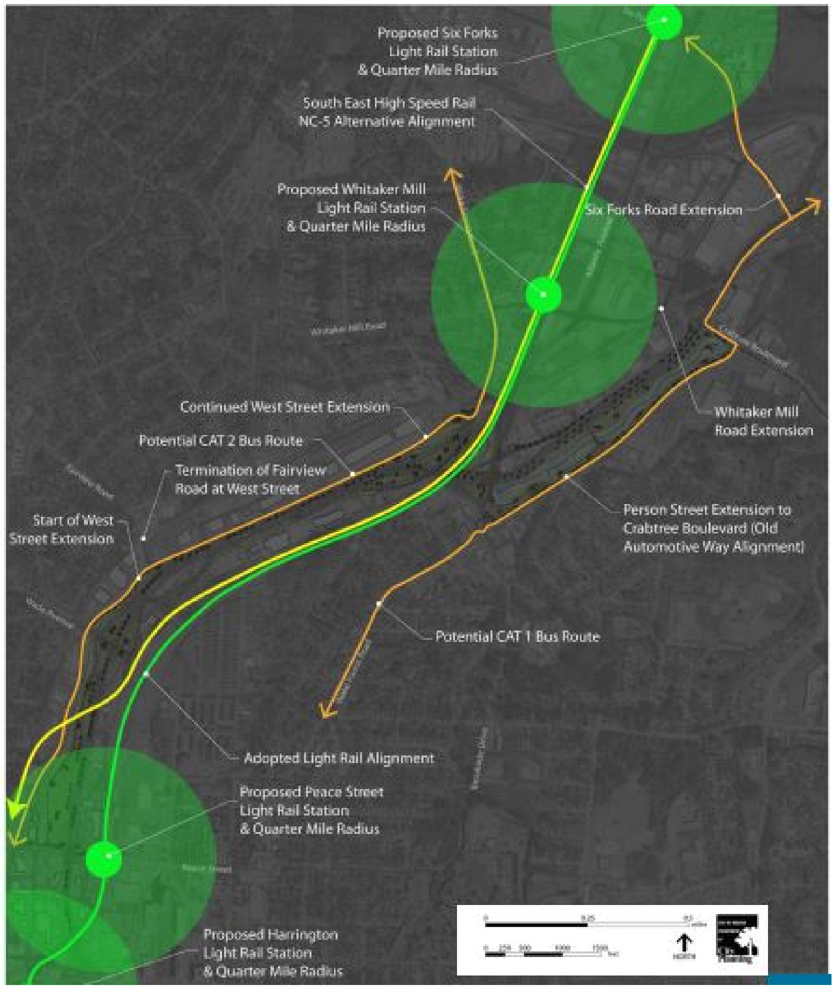
Figure 9. Location of Recommendations in Western Boulevard Corridor

1	Gorman Street: Complete Gaps in Sidewalk
2	Gorman Street: Buffered Bicycle Lane
3	Faucette Drive: Improve Transit Stop (Shelter/Bicycle Rack)
4	Faucette Drive: Complete Gaps in Sidewalk
5	Faucette Drive: Create Two-Way Cycle Track
6	East of Gorman/Southside: Resurface and Widen Greenway/Sidepath
7	East of Gorman/Southside: Pedestrian-Scale Lighting
8	Varsity Drive/Northside: Sharrows
9*	Various Intersections: High Visibility Crosswalks
10*	Various Intersections: Red pavement markings at conflict points / intersection approaches
11	Varsity Drive/Southside: Bicycle Lane
12	East of Dan Allen/Southside: Improve Transit Stop (Bench/Shelter)
13	Dan Allen to Avent Ferry: Install Median Fencing / Replace Landscaping
14	Avent Ferry/Southside: Mid-Block Crossing
15	Avent Ferry: Pork Chop Island / Turn Lane Rerouting
16	Avent Ferry: Textured/High Visibility Crosswalks
17	East of Crusader Drive/Southside: Pedestrian-Scale Lighting
18	Pullen Road: Bulb-Out Extension
19	Pullen Road Bridge: Sidewalks and Bicycle Lanes
20	Pullen Road Extension / Roundabout: Adjacent Sidepath
21	Closure of Bilyeu Street at Western Boulevard; Re-Design of Ashe Avenue access
22	Avent Ferry/Morrill Drive: Bicycle and Pedestrian Tunnel Under Western Boulevard

[12] https://facilities.ofa.ncsu.edu/files/2015/04/Western-Boulevard-Crossing-Study-Capital-Area-Metropolitan-Planning-Organization-2013.pdf

CAPITAL BOULEVARD CORRIDOR STUDY[13]

The Capital Boulevard Corridor Study, adopted in 2012, was developed by the City of Raleigh in coordination with community leaders, residents, business owners, and other stakeholders. The vision of the study is to develop a strategy for "revitalization, redevelopment, and renewal of Capital Boulevard from Downtown to the I-440 Beltline". Capital Boulevard is a highly traveled gateway into Raleigh and has been neglected for improvements. This plan is a part of a city and regional process to enhance the corridor's local and regional significance through programmed infrastructure improvements, transit investment, and mobility considerations. The plan outlines the vision for the boulevard, including recommendations for improving transit service and infrastructure within the corridor and a plan to phase implementation of the recommended improvements over time. It calls for improved transit access within the corridor by providing new bs routes, improving the pedestrian realm, and capitalizing on future rail investments. The plan considers the planned regional transit improvements surrounding the Capital Boulevard corridor and intends to connect local transit service along the corridor to these regional facilities. The plan offers the following recommendations:

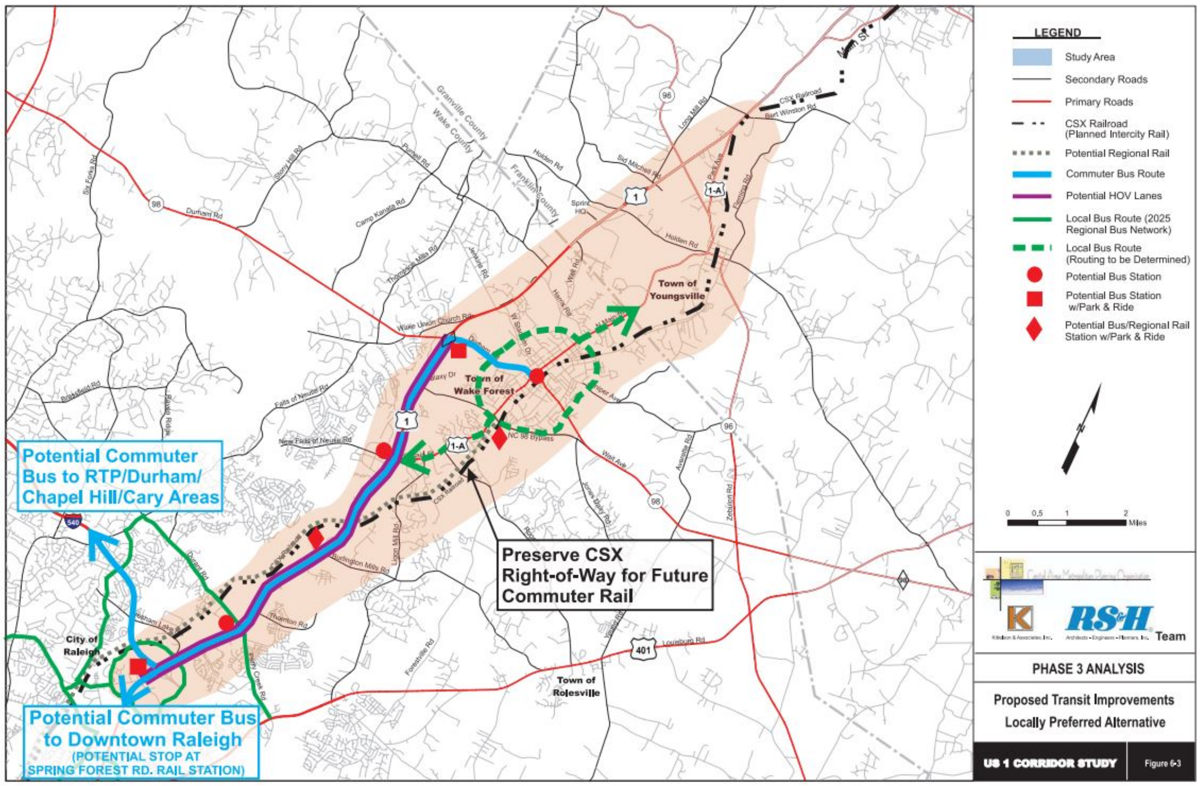


- Extend Johnson and Harrington Streets to intersect with Peace Street.
- Add bike lanes and widen sidewalk on Peace Street.
- Add a landscaped median and widen sidewalks on Capital Boulevard.
- Construct a greenway to extend from West Street to the Wade Avenue off-ramp.

[13] https://www.raleighnc.gov/content/PlanDev/Documents/UrbanDesign/CapitalBlvd/CapitalBlvdFinal-08-09-12.pdf

US 1 CORRIDOR STUDY: PHASE I[14]

The US 1 Corridor Study was published in 2006 and commissioned by CAMPO. The study area, referred to as Capital Boulevard, extends from I-540 in Raleigh to Park Avenue in Franklin County. The purpose of this study was to develop a locally-preferred alternative (LPA) for a multimodal corridor with high mobility. The plan analyzed existing conditions and solicited public feedback on proposed plans to develop the LPA. The recommended LPA includes two commuter bus routes that may benefit from transit priority treatments in the future: one from Wake Forest to downtown Raleigh and the other from Wake Forest to the Research Triangle Park (RTP). Both routes would operate on NC 98 west to US 1, then south on US 1 to I-540, where the routes would split – the downtown Raleigh route using US 1 and the RTP route using I-540. The recommended bus service would operate with transit signal priority (TSP) and/or queue jumps and, as US 1 is converted to a freeway facility (per NCDOT Strategic Transportation Corridors plans), the bus or BRT service could operate on the road shoulders.



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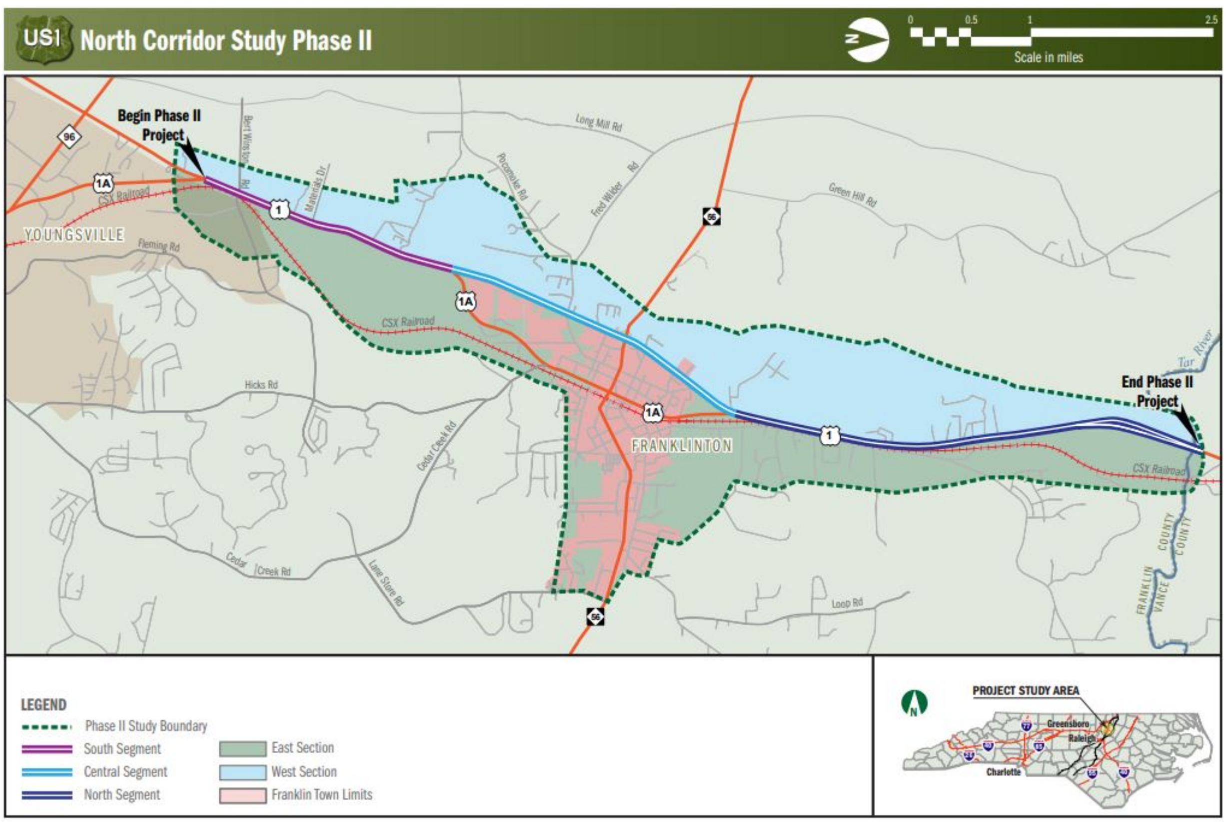
[14] https://www.ncdot.gov/projects/us-1-corridor/Documents/us1_corridor_report.pdf

US 1 CORRIDOR STUDY: PHASE II[15]

Phase II of the US 1 Corridor Study was initiated in 2011 by CAMPO and Franklin County. This study area includes a segment of US 1 that includes the Town of Franklinton and a portion of the Town of Youngsville, as well as the CSX Railroad. The goal of this study is to produce a plan for the corridor that considers existing land uses and projected growth patterns to make relevant recommendations for a multimodal corridor. To develop context appropriate recommendations, the corridor was divided into three segments: South Segment, Central Segment, and North Segment; additionally, the study area was divided into an East Section and a West Section. All modes of travel were assessed for this corridor and recommendations were developed for each. Recommendations for transit service include: to provide transit mobility for commuters; establish park & ride locations as a short term solution to regional mobility; and a long-term solution connects Franklinton to regional destinations by express bus service.



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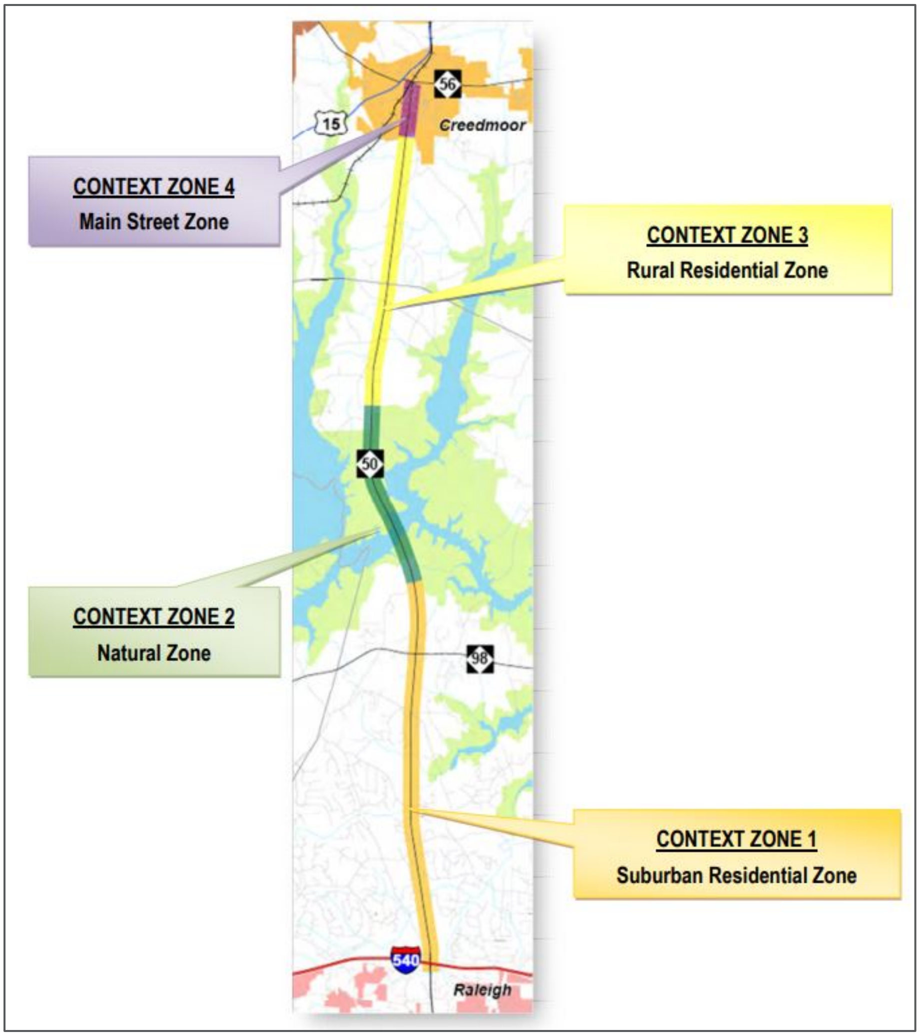
[15] http://www.us-1corridornorth.com/US1Docs/US1Ph2/ExecutiveSummarywithFigures-US1Study9-10-12.pdf

NC 50 Corridor Study[16]



Published in January 2011, the NC 50 Corridor Study is a joint effort of CAMPO and NCDOT. Three project deliverables were generated during the study process: Existing Conditions Report, NC 50 Workbook and NC 50 Playbook. The Existing Conditions Report summarizes conditions for transportation, land use, and environment. The Playbook explains the strategy for the NC 50 corridor; and the Workbook presents recommendations and a detailed Action Plan for implementing priority projects that achieve the community's vision for NC 50. The Workbook was reviewed for the purposes of the CAMPO RED lanes study and includes recommendations for multimodal transportation mobility and safety, as well as context-sensitive roadway improvements that satisfy the travel needs of multimodal users.

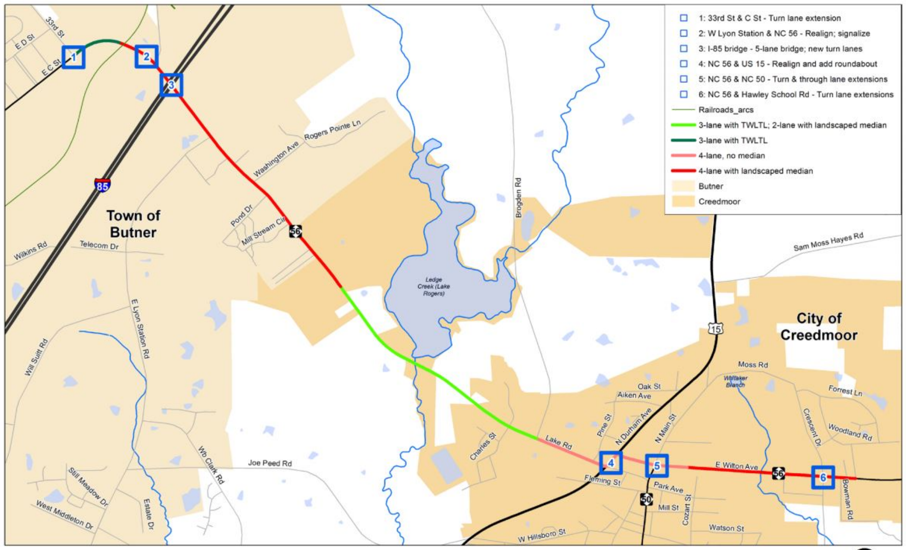
NC 50 is a two-lane, regionally significant corridor that serves growing suburban residential populations around I-540 in North Raleigh and in southern Granville County near the City of Creedmoor. The study covers the NC 50 corridor from I-540 in Wake county to NC 56 in downtown Creedmoor, approximately 15 miles. When considering the study area using a context-sensitive approach, four distinct context zones appear each requiring unique design treatments: Suburban Residential Context Zone, Natural Context Zone, Rural Residential Context Zone, and Main Street Context Zone.

High frequency transit is not planned on the NC 50 corridor for the 2035 horizon year, although express bus is recommended as a long-term solution.

[16] http://files.www.campo-nc.us/programs-studies/corridor-studies/NC_50/NC_50_Workbook_FINAL_reduced.pdf

NC 56 CORRIDOR STUDY

The NC 56 Corridor study, completed in June 2015, was a combined planning effort of CAMPO, Town of Butner, City of Creedmoor, Granville County, NCDOT, and the Kerr-Tar Rural Planning Organization (RPO). The extent of the study is a 4.5-mile section of NC 56 between 33rd Street in Butner and Darden Drive in Creedmoor. This study defines a long-term vision for the corridor, a key east-west connection through south Granville County serving the Town of Butner and City of Creedmoor that provides travelers with local accessibility to commercial, institutional, and residential land development, and regional mobility as a critical connection to I-85. The plan proposes a combined strategy of short-term operations improvements, long-term infrastructure investments, and coordinated policies. Sections of the corridor vary tremendously in traffic volume, adjacent land uses, and expected development; therefore, the corridor was separated into three distinct segments: western, middle, and eastern. Recommendations for each segment are as follows:



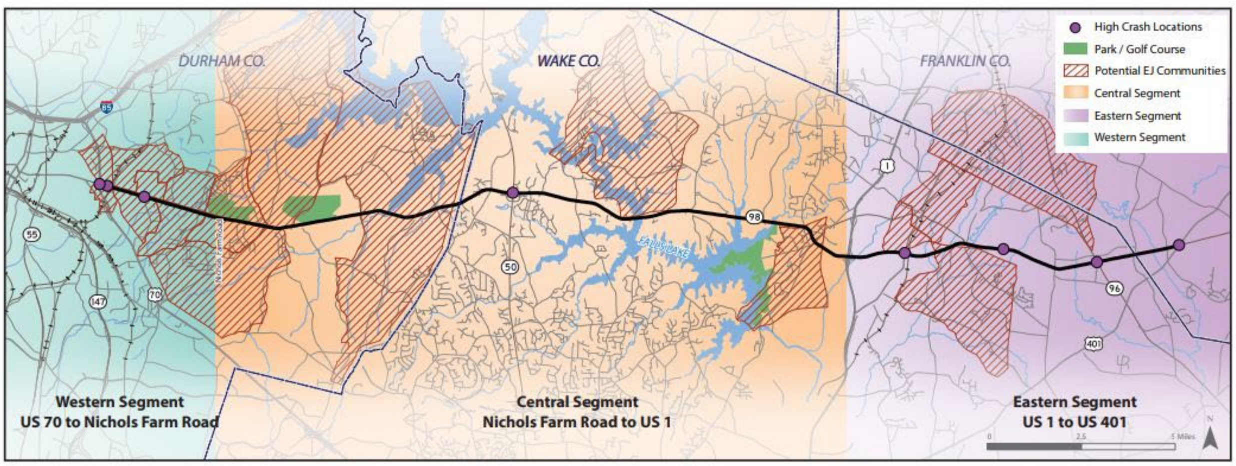
NC 56 Corridor Study - Year 2040 Recommendations Overview

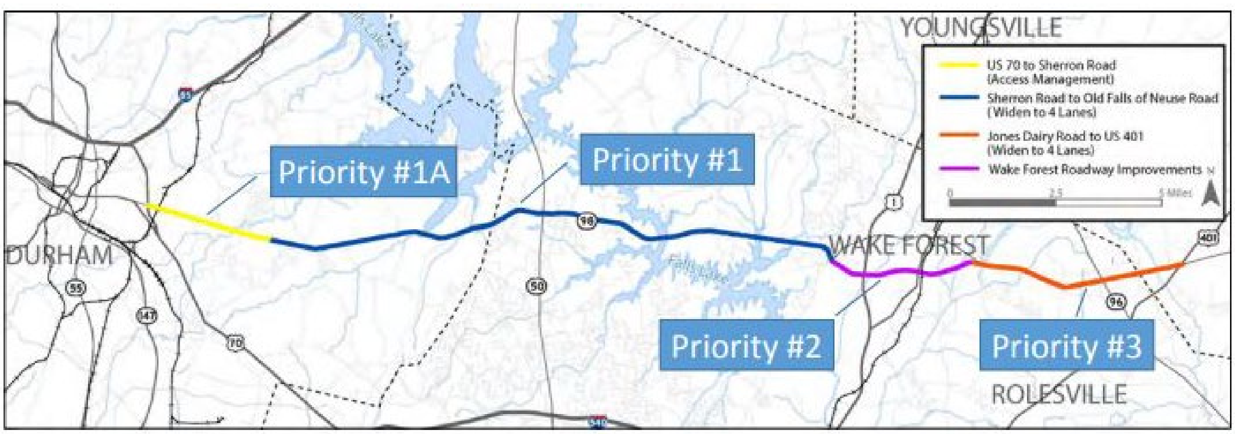
- Western Segment:
    - Widen to a 3-lane segment from 33rd Street to the at-grade railroad crossing west of West Lyon Station Road.
    - Widen to a 4-lane divided section beginning at the at-grade railroad crossing, and ultimately extending east to approximately the Butner Town Limits.
    - Widen the bridge over I-85 to 5 lanes
- Middle Segment:
    - Widen to a 3-lane section from approximately the Butner Town Limits east to Brogden Road
- Eastern Segment:
    - Widen to a 4-lane section from Brogden Road to a point approximately 800 feet east of North Main Street
    - Widen to a 3-lane segment from approximately 800 feet east of North Main Street to Darden Drive (Figure ES-3).

NC 98 CORRIDOR STUDY[17]

The NC 98 Corridor Study, initiated in December 2016, was adopted in July 2018. NC 98 is an important connection between Franklin, Wake, and Durham Counties. The extent of this corridor study originates at US 70 in Durham County, runs through Wake County, and terminates at US 401 in Franklin County. The study evaluates several transportation elements, including: safety and mobility, planned and existing roads, bicycle and pedestrian facilities, and transit. To develop context sensitive recommendations, the corridor was divided into three segments: west, central, and east. Overall, the corridor is expected to experience tremendous growth relative to existing conditions; approximately 20,000 new housing units and 17,000 new jobs are anticipated in the corridor, the majority of which are expected in the eastern segment. While transit is not expected to be a major component of travel on the NC-98 corridor in the near or intermediate future, strong growth in areas served by the corridor may prompt its consideration for longer-term implementation of transit priority lanes. The plan recommends the following long-term improvements that may be relevant to the CAMPO RED lanes study:

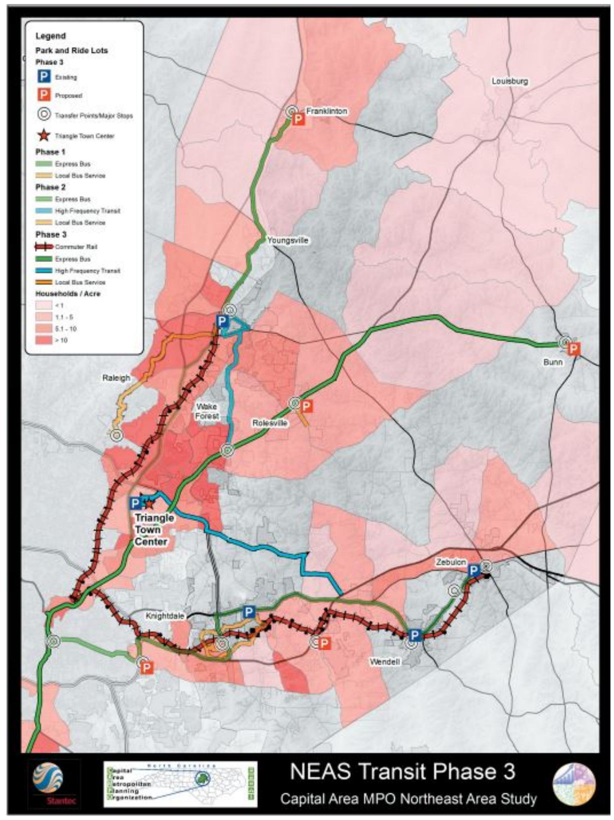
- Widen the central segment of NC 98 from Sherron Road to Old Falls of Neuse Road.
- Widen the eastern segment of NC 98 from Jones Dairy Road to US 401.





[17] http://www.nc98corridor.com/pdfs/final%20nc%2098%20corridor%20study%20report%20100318.pdf

NORTHEAST AREA STUDY[18]



The Northeast Area Study (NEAS) is a visionary planning document published in 2014. The study was initiated by CAMPO to define a transportation strategy for the communities in the Northeast area of the CAMPO region, including: Wake Forest, Knightdale, Raleigh, Wendell, Zebulon, Rolesville, Bunn, Franklinton, and Youngsville. The study integrates land use and transportation factors to identify cost-feasible recommendations. These recommendations represent a blend of current contexts and community input and are representative of a long-term view of the region. A roadway connectivity element was examined and recommends the construction and widening of major arterials, improved access management, and increased mobility and connectivity. The study area is not adequately served by transit and currently does not have the activity density to support high frequency service; however, future growth projections will require more reliable, frequent transit service in the study area. The study recommends transit service implementation, either through commuter rail, fixed-route bus, or express bus, in short-term, medium-term, and long-term timelines.

- Short term recommendations
    - Expanded Local Service – Wake Forest to Raleigh (Shorter Headways)
    - Express Bus – Zebulon to Raleigh (Shorter Headways)
    - Local Service – Rolesville to Raleigh
    - Local Service – Knightdale Circulator Bus Service
- Medium term recommendations
    - High Frequency Transit – Wake Forest to Triangle Town Center
    - High Frequency Transit – Wendell to Triangle Town Center
    - Express Bus – Franklinton to Raleigh
    - Express Bus – Bunn to Raleigh
- Long term recommendations
    - Commuter Rail – Zebulon to Raleigh
    - Commuter Rail – Wake Forest/Franklinton to Raleigh

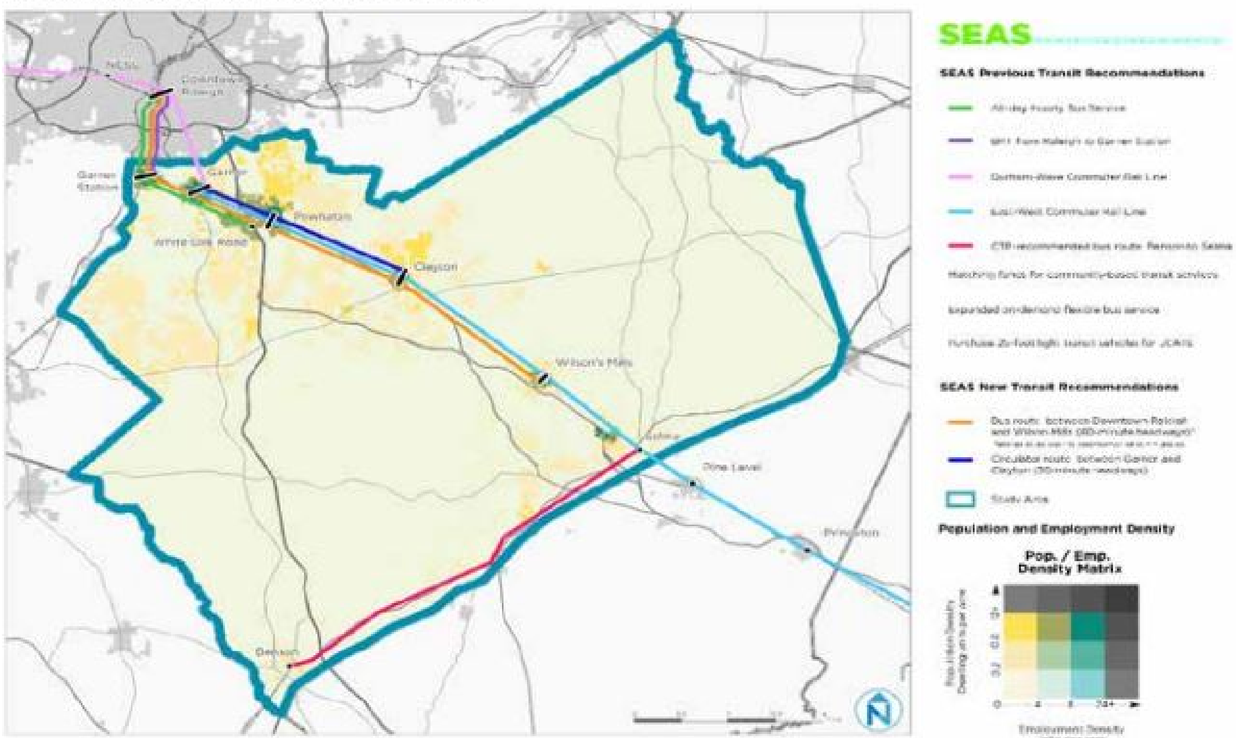
[18] http://www.campo-nc.us/programs-studies/area-studies/northeast-area-study

Southeast Area Study[19]

The Southeast Area Study was published in 2017 and represents a collaborative effort of CAMPO and 11 municipalities, Archer Lodge, Benson, Clayton, Four Oaks, Garner, Kenly, Micro, Raleigh, Selma, Smithfield, and Wilson's Mills. This document identifies strategies to establish a multimodal transportation system in the southeast area of the CAMPO region, which includes a southern portion of Wake County and portion of Johnston County. Additionally, the recommendations that come out of this study inform transportation planning by the MPO and for Johnston County. The study utilized scenario planning to develop appropriate recommendations that would align with future growth in the area. The following service improvements are recommended as a part of this study:

1. An all-day bus service with 60-minute headway from White Oak Road between Garner and Clayton to downtown Raleigh
2. A bus route between Selma and Benson
3. BRT service between Raleigh and Garner Station
4. A bus route between Raleigh and Wilson's Mill with 60-minute headway
5. A circulator route between Garner and Clayton with 30-minute headway

Recommended Transit Improvements

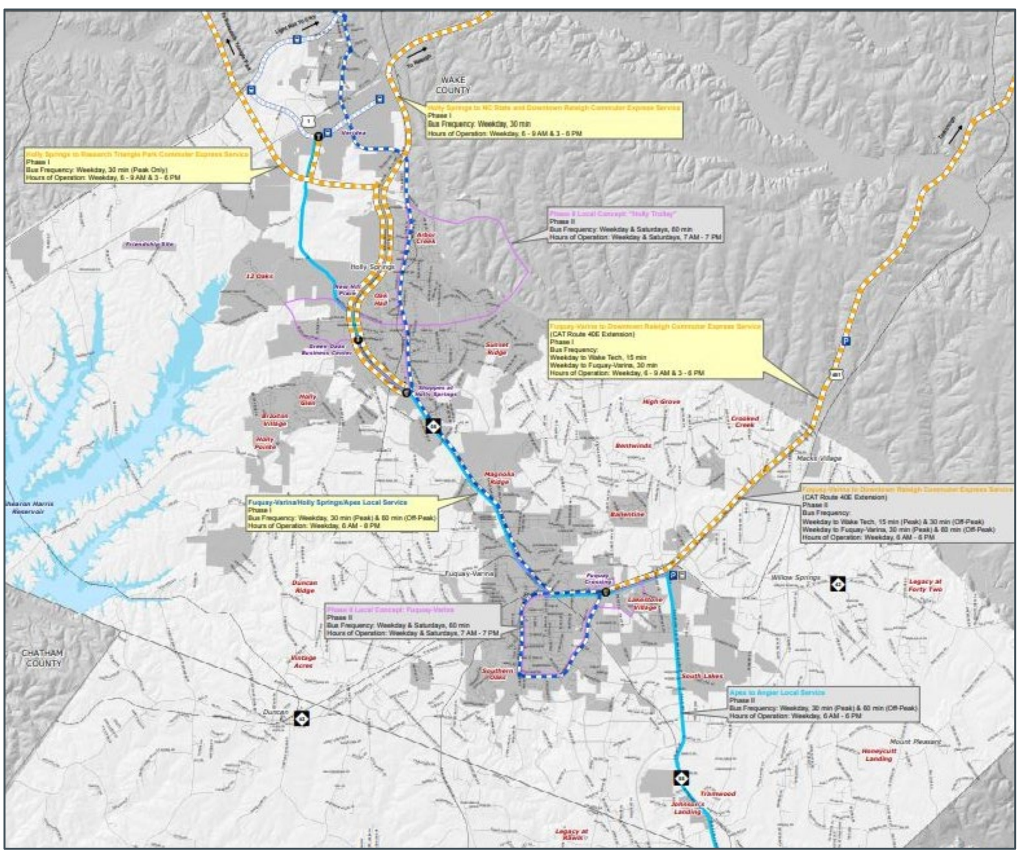


19 http://files.www.campo-nc.us/programs-studies/area-studies/southeast-area-study/SEAS_Final_Report_1-3.pdf

Southwest Area Study[20]

CAMPO commissioned a study in 2012 for the southwest area of the region – covering the southwest portion of Wake County and northern Harnett County. This plan aims to address the tension between the growing demand of commuters on transportation facilities and the increasing density of development in this area. A multimodal, context appropriate solution is required to address these different demands. The study utilized scenario planning that considered land use, environmental factors, and transportation to address issues between those competing interests. A multimodal future includes phased implementation of high quality transit in the study area. This document recommends the following transit service enhancements, specifying frequency and service hours:

- Phase I Recommendations
  - Holly Springs to RTP Commuter Express Service
  - Holly Springs to NC State and Downtown Raleigh Commuter Express Service
  - Fuquay-Varina to Downtown Raleigh Commuter Express (CAT Route 40E Extension)
- Phase II Recommendations
  - Fuquay-Varina to Downtown Raleigh Commuter Express (CAT Route 40E Extension)
  - Local service – Fuquay Varina
  - Local service – "Holly Trolley"
  - Local service – Apex to Angier



[20] http://www.southwestareastudy.com/

Ongoing Plans and Studies

Regional Technology Integration Study [21]

The Regional Technology Integration Study is funded by Wake Transit Plan and GoTriangle. The study effort is being led by GoTriangle. The plan intends to identify existing technologies in use among transit operating agencies in Wake County as well as GoDurham and Chapel Hill Transit. Examples of relevant technologies include fare-box equipment or mobile fare payment options, camera systems, automatic vehicle location (AVL) systems, mobile and fixed passenger information systems or electronic signs, automatic passenger counters (APC) and scheduling and dispatch software packages for fixed route, on-demand and paratransit services. Understanding these technologies and their use across the region could reveal opportunities to improve operations, information sharing, performance measurement, fare collection, etc.

Commuter Corridors Study

In 2018, CAMPO released a Request for Proposals for a consultant to conduct a Commuter Corridor Study "to address select, congested commuter corridors to improve mobility in the CAMPO planning area located in Wake County and parts of Franklin, Granville, Harnett and Johnston Counties." These corridors are congested and are forecast to continue to be congested by 2045, even with transportation investments. The study will analyze existing transportation data and recommend investments and policies to relieve expected congestion on commuter corridors. The study is being conducted in FY 19 and should conclude by June 30, 2019.

Raleigh Downtown Transportation Plan[22]

The City of Raleigh, in partnership with CAMPO, GoTriangle, and NCDOT, is leading the development of a Downtown Transportation Plan. The study will build on the Wake Transit Plan by defining a plan for transit, transportation, and mobility in Downtown Raleigh. This plan envisions a multimodal transportation network that serves all transportation needs, including automobile, bicycle, pedestrian, and public transportation users. The plan will recommend improvements for the next 10 years. The city is currently soliciting public feedback on the plan. This study is different from but complementary to the City of Raleigh Downtown Plan summarized above.

Raleigh Union Station Phase II – RUS BUS[23]

The first phase of Raleigh Union Station – an Amtrak station in downtown Raleigh – was completed in 2018. The second phase of this project is the construction of an adjacent bus facility, referred to as "RUS BUS". The bus facility will provide access to the regional and local bus network as well as the Amtrak station. The development partners (GoTriangle, City of Raleigh, Wake County, and NCDOT) applied for a BUILD grant in 2018 to implement the bus facility plan.

Western Boulevard Corridor Plan

The City of Raleigh initiated the Western Boulevard Corridor Plan. Similar to the Capital Boulevard and New Bern Avenue Corridor Plans, the Western Boulevard Corridor Plan will prepare the corridor for future BRT

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[21] http://goforwardnc.org/project/technology-integration-study/

[22] https://goraleigh.org/downtownplan

[23] http://rusbusnc.com/

service. This plan will analyze intersections, transit operations, and infrastructure needs to address multimodal travel demand in the corridor and is expected to have a strong bike/ped component.

Avent Ferry Road Corridor Study[24]

The City of Raleigh is in the process of conducting the Avent Ferry Road Corridor Study. The overall goal of this study is "to plan for and implement a safe, vibrant corridor for pedestrians, cyclists, transit-users and motorists that helps enhance livability and economic viability." This study will develop a community-driven vision for the transformation of Avent Ferry Road to a multimodal corridor of importance in the future. The study incorporates technical analysis and community feedback to generate recommendations that align with the overall goal of this study. The recommendations for this study fall into three categories: (1) develop a distinct district; (2) adopt "Complete Streets" principles; and (3) foster redevelopment and economic viability.

Midtown-St Albans Area Plan[25]

The Midtown-St. Albans Plan aims to develop a vision to guide future investment and development in midtown Raleigh, an area that has changed rapidly and substantially over the past decade. A key objective of the Midtown-St. Albans Area Plan is to consider the transportation impacts of recent land use changes on existing and proposed transportation infrastructure in the Midtown area. The goal of the planning process is to involve the community in shaping the growth and development of the area so that decisions are made that meet the needs of residents, employees, and visitors.

Capital Boulevard North Corridor Study[26]

The Capital Boulevard North Corridor Study will create a vision and policies to guide investment and development on Capital Boulevard between I-440 and I-540. The city will select a consulting team in the coming months and the consulting team will lead the study under the direction of city staff. A Vision and Goals Summary has been developed for this study. This vision is based on community input and the goal statements will aid the consulting team in evaluating the alternatives and recommendations in the next phase of this study.

Falls of Neuse Area Plan Update[27]

The Falls of Neuse plan was adopted in 2006. It contains policies that cover land use, roadway improvements, and balancing development in an urban watershed area. The plan update seeks to focus on four main topics:

- Development opportunities created by planned expansion of transit service.
- Results of the implementation of the Falls of Neuse Road roadway project, and potential future changes.
- Land use policies for watershed protection.

[24] https://www.raleighnc.gov/business/content/PlanDev/Articles/UrbanDesign/AventFerryCorridorStudy.html

[25] https://www.raleighnc.gov/business/content/PlanDev/Articles/LongRange/MidtownStAlbans.html

[26] https://www.raleighnc.gov/business/content/PlanDev/Articles/LongRange/CapitalBlvdNorth.html

[27] https://www.raleighnc.gov/business/content/PlanDev/Articles/LongRange/FallsofNeuse.html

- Identification of future land uses and scale of development on undeveloped parcels that are supported by the market and community.

Downtown Cary Multimodal Transit Facility [28]

The Town of Cary is studying the feasibility of a new Multi-Modal Transit Facility in downtown Cary. The study will evaluate proposed Bus Rapid Transit (BRT) corridors into downtown Cary and potential site locations for a Multi-Modal Transit Facility. The Multi-Modal Transit Facility will serve a variety of transit modes, such as local and regional bus service, BRT, future commuter rail service and Amtrak intercity passenger rail services, as well as commuter parking options. The study is expected to be completed by fall 2019.

Southwest Area Study Update [29]

CAMPO is updating the Southwest Area Study in 2018 in cooperation with Wake County, Harnett County, Apex, Angier, Holly Springs, Fuquay-Varina, and transportation agencies. This study will define a long-term, multi-modal vision for southwestern Wake and northeastern Harnett Counties. The study will examine safety and mobility of existing and planned roads, transit service, and bicycle and pedestrian facilities. Finally, a set of recommendations will be provided to help guide future growth and accommodate future transportation needs. The study should be completed by mid-2019.

Additional Plans

The following plans from CAMPO participating jurisdictions were also reviewed for this study. They are not summarized in this report but are recommended as additional reading on local and regional planning priorities throughout the CAMPO region.

- NCDOT State Transportation Improvement Program (STIP)
- Triangle Regional ITS Strategic Deployment Plan (SDP)
- Wake Transit Plan – Adopted FY 19 Work Plan
- Zebulon 2035 Multimodal Transportation Plan
- Wendell Arterial and Collector Street Plan
- Wake Forest Transportation Plan
- Knightdale Comprehensive Plan
- Morrisville Comprehensive Transportation Plan
- Holly Springs Comprehensive Transportation Plan
- Garner Transportation Plan
- Fuquay-Varina Community Transportation Plan
- Cary Community Plan and Comprehensive Transportation Plan
- Creedmoor 2030 Land Use & Comprehensive Master Plan
- Apex Comprehensive Land Use Plan
- Angier Comprehensive Plan
- Rolesville Comprehensive Plan

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[28] https://townofcary.org/projects-initiatives/project-updates/facilities-projects/downtown-cary-multi-modal-transit-facility

[29] https://www.swastudy.com/

CANDIDATE CORRIDORS

The review of regional plans frames regional planning priorities, as outlined in the above sections of this report. The plans and studies highlighted also identify corridors and potential projects where the application of RED lanes may be suitable. This section of the report provides a list of initial candidate corridors for consideration in a RED lanes evaluation/prioritization process.

Candidate corridors were identified from the plans highlighted in this report as well as from NCDOT's State Transportation Improvement Program (STIP) database. In general, the goal was to be inclusive and identify potential candidate corridors even when transit was not emphasized in the planning documents, although many of the corridors listed have been the subject of transit plans. Therefore, if a corridor was mentioned as a part of a plan or study summarized in this report, it has been included among the candidate corridors. In addition, highway projects listed in the STIP within the CAMPO region were identified and included as candidate corridors. STIP projects "under construction" or on limited access highways/tollways have not been included.

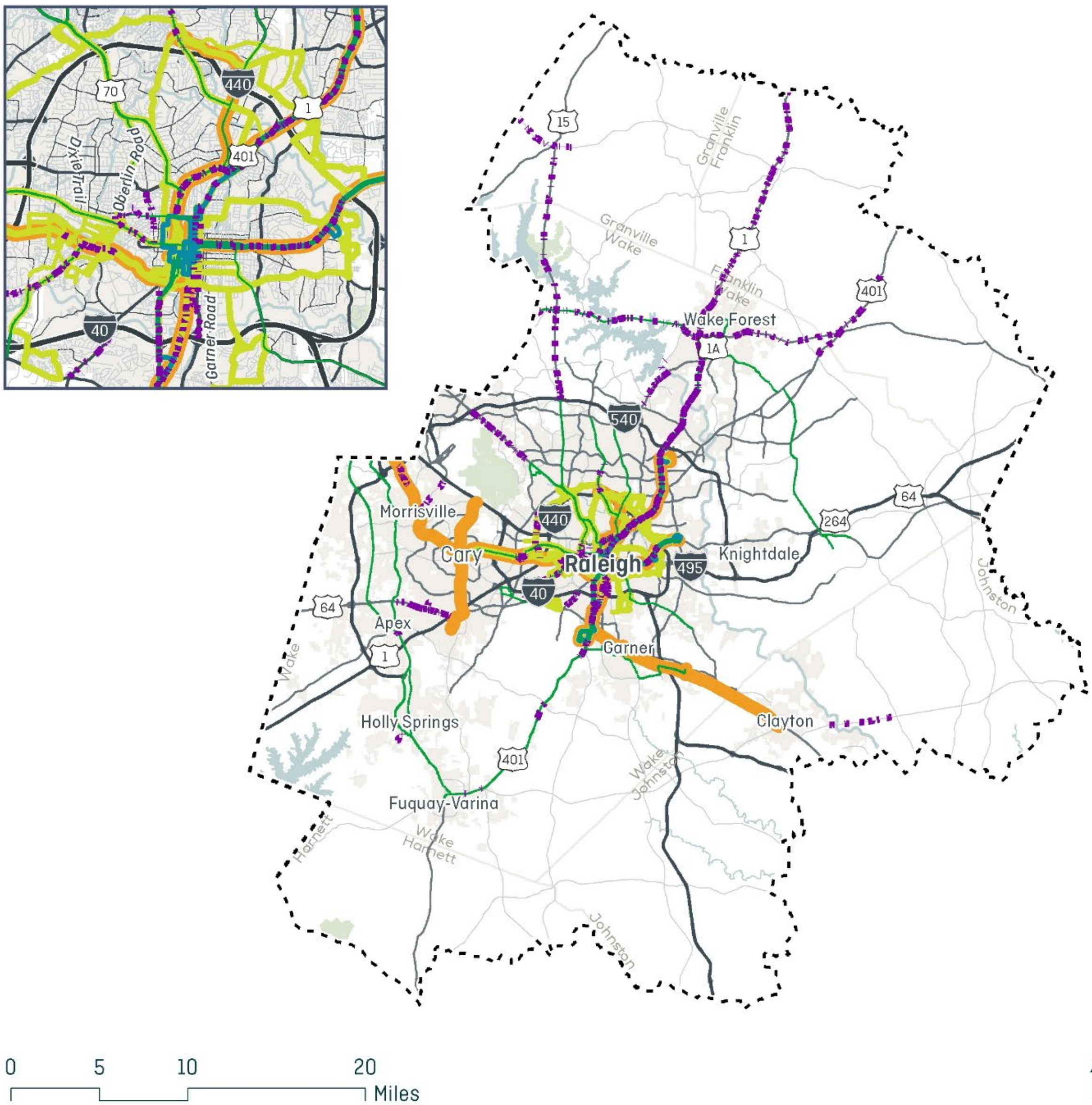
The preliminary set of corridors may change over time. Each corridor's relationship to different planning documents and role in the existing and planned transit system for the CAMPO region has been demarcated in the list. Corridors with no role or a limited role in the regional transit network may be dropped from the list, since RED lanes are likely to have limited relevance or applicability in these corridors. Yet, retaining these corridors in the evaluation process may be desirable to understand their long-term potential for RED lanes or other transit enhancements, even if the evaluation results do not rank them highly.

On the other hand, corridors may be added to the list based on an analysis of existing conditions and trends. This analysis will occur in a later phase of the CAMPO RED Lanes Study; it may reveal areas or corridors in the region that are suitable for transit investment, but which have not yet been the subject of transit plans or studies.

A map of the CAMPO region and candidate corridors is provided below, followed by a table listing the preliminary set of candidate corridors for RED lanes evaluation. In the table, each corridor is listed and information about existing transit service, plan documents, and transit-related recommendations are noted by segment. In some cases, small collections of segments are grouped by sub-area or with a larger corridor. For each segment, existing transit services are noted alongside indications of the segment's inclusion in various planning documents, as follows:

- The segment's role in the Wake Transit Plan is noted, either as having been identified for BRT or high-frequency transit service (HF).
- The segment's inclusion in the Wake Bus Plan is also noted with the year of implementation (2024 or 2027) and differentiating between planned high frequency service (HF) or other fixed route service (bus)
- If transit service is denoted in the long-range Metropolitan Transportation Plan (MTP), the type of service is noted – BRT, high frequency (HF), or other fixed route service (bus).
- If the segment has been identified as a premium transit corridor or commuter transit corridor in a prior regional transit/transportation plan, such as the Wake County Comprehensive Plan or 2012 GoTriangle SRTP, this is noted.
- If the segment has been the focus of a corridor or small area study, the relevant study is noted.
- If there is a STIP project on the segment, the project ID number if provided.

RED LANES | PRELIMINARY CANDIDATE CORRIDORS



Fixed Route Bus Service

- Existing High Frequency Network (15-min. max headway)

Corridors highlighted in plans and studies

- High Frequency Network (15-min. max headways in WTP, WBP, or MTP)
- Bus Rapid Transit (BRT)
- Corridors in other transit plans (prior to WTP)
- Other studies/projects

CORRIDOR/SUBAREA									
Segment	From	To	Existing Transit Service (HF = High Frequency)	Wake Transit Plan (BRT, HF)	Wake Bus Plan (HF, Bus = fixed route transit)	MTP 2045 Long Range Plan (BRT, HF, Bus)	Other transit plan (pre-WTP)	Corridor/ Sub-Area Study	NCDOT STIP
ATLANTIC AVE									
Atlantic Ave	Automotive Way	New Hope Church Rd	Yes	HF	HF (2024)	Bus			
Atlantic Ave	New Hope Church Rd	Six Forks Rd	Yes		Bus (2027)	HF			
BLOUNT ST/PERSON ST									
Hammond Rd	I-40	Hoke St	Yes		Bus (2024)	Bus		Blount St-Person St Corridor Study	
Blount St	Hoke St	MLK Jr Blvd	Yes		Bus (2024)	Bus			
Blount St	MLK Jr Blvd	Davie St	Yes		HF (2024)	Bus			
Blount St	Davie St	New Bern Ave	Yes (HF)		HF (2024)	HF			
Person St	Hoke St	MLK Jr Blvd	Yes		Bus (2024)	Bus			
Person St	MLK Jr Blvd	New Bern Ave	Yes		HF (2024)	Bus			
Person St	New Bern Ave	Peace St			HF (2027)	HF			
Person St	Peace St	Delway St	Yes (HF)		HF (2024)	Bus			
BLUE RIDGE RD									
Blue Ridge Rd	Western Blvd	Hillsborough St		HF	HF (2024)	HF		Blue Ridge Road District Study	
Blue Ridge Rd	Hillsborough St	Wade Ave	Yes	HF	HF (2027)	HF			
Blue Ridge Rd	Wade Ave	Lake Boone Tr		HF	HF (2027)	HF			
Blue Ridge Rd	Lake Boon Tr	Glenwood Ave	Yes	HF	HF (2027)	HF			
Crabtree Valley Ave	Blue Ridge Rd	Creedmoor Rd	Yes		HF (2024)	HF			
Trinity Rd	Edwards Mill Rd	Blue Ridge Rd	Yes		Bus (2024)	HF			
CAMERON VILLAGE									
Peace St/Clark Ave	Oberlin Rd	Glenwood Ave	Yes			Bus	Yes	Cameron Village - Hillsborough	
Peace St	Glenwood Ave	Person St	Yes (HF)		Bus (2024)	HF	Yes		

CORRIDOR/SUBAREA									
Segment	**From**	**To**	**Existing Transit Service (HF = High Frequency)**	**Wake Transit Plan (BRT, HF)**	**Wake Bus Plan (HF, Bus = fixed route transit)**	**MTP 2045 Long Range Plan (BRT, HF, Bus)**	**Other transit plan (pre-WTP)**	**Corridor/ Sub-Area Study**	**NCDOT STIP**
Oberlin Rd	Hillsborough St	Clark Ave		HF	HF (2024)	HF		Street Small Area Plan	
Oberlin Rd	Clark Ave	Glenwood Ave	Yes	HF	HF (2024)	HF	Yes		
St Marys St	Hillsborough St	Wade Ave	Yes						
St Marys St	Glenwood Ave	Scotland St	Yes	HF	HF (2024)	HF			
CAPITAL BLVD/US 1 NORTH									
Capital Blvd	Lane	Peace St	Yes		HF (2024)	BRT			
Capital Blvd	Peace St	Wake Forest Rd	Yes	BRT	HF (2024)	BRT	Yes	Capital Blvd Cor. Study	
Capital Blvd	Wake Forest	I-440	Yes (HF)	HF	HF (2024)	BRT	Yes		
Capital Blvd	I-440	Louisburg Rd	Yes (HF)	HF	HF (2024)	BRT	Yes	Capital Blvd N. Cor. Study	
Capital Blvd	Louisburg Rd	Sumner Blvd	Yes (HF)	HF	HF (2024)	BRT	Yes	US 1 Ph I	
Capital Blvd	Sumner Blvd	Durant Rd	Yes		Bus (Yes)	Bus	Yes	US 1 Ph I	U-5307 A/B/C/D
Capital Blvd	Durant Rd	NC 98	Yes		Bus (Yes)	Bus	Yes	US 1 Ph I	
Capital Blvd	NC 98	Durham Rd						US 1 Ph I	
US 1	Durham Rd	Harris Rd						US 1 Ph I	
US 1	Harris Rd	Vance County Line						US 1 Ph II	
US 1 Alt | Main St	Capital Blvd	Elm Ave	Yes		Bus (2024)	Bus	Yes		
CHATHAM ST/EAST CARY BRT CORRIDOR									
Chatham St	Academy St	Ne Maynard Rd	Yes	BRT	HF (2027)	BRT	Yes		
Hillsborough St	Ne Maynard Rd	Jones Franklin Rd	Yes	BRT	HF (2027)	BRT	Yes		
DOWNTOWN RALEIGH									
Cabarrus St	West St	Salisbury St	Yes (HF)			HF			
Davie St	Harrington St	Person St	Yes (HF)		HF (2024)	Bus			
Davie St	Person St	Rock Quarry Rd			Bus (2024)	HF			
Dawson St	MLK Jr Blvd	Morgan	Yes (HF)		HF (2024)	BRT	Yes		

CORRIDOR/SUBAREA									
Segment	**From**	**To**	**Existing Transit Service (HF = High Frequency)**	**Wake Transit Plan (BRT, HF)**	**Wake Bus Plan (HF, Bus = fixed route transit)**	**MTP 2045 Long Range Plan (BRT, HF, Bus)**	**Other transit plan (pre-WTP)**	**Corridor/ Sub-Area Study**	**NCDOT STIP**
Dawson St	Morgan	Lane St	Yes		HF (2024)	BRT			
Hargett St	West St	Person St	Yes (HF)		HF (2024)	HF			
Harrington St	Davie St	Edenton St	Yes (HF)						
Lenoir St	Boylan Ave	Wilmington St	Yes		HF (2027)	Bus			
Lenoir St	Wilmington St	Rock Quarry Rd	Yes	HF	HF (2024)				
McDowell St	MLK Jr Blvd	Morgan	Yes (HF)		HF (2024)	BRT	Yes		
McDowell St	Morgan	Lane St	Yes		HF (2024)	BRT			
Martin St	West St	McDowell St			HF (2024)	BRT			
Martin St	McDowell St	Person St	Yes (HF)		HF (2024)	HF			
Morgan St	Glenwood Ave	Dawson St	Yes (HF)			HF			
Morgan St	Dawson St	Wilmington St	Yes			BRT			
Morgan St	Wilmington St	Person St	Yes (HF)		Bus (2024)	BRT			
Salisbury St	Peace St	Edenton St	Yes		Bus (2024)	Bus			
Salisbury St	Edenton St	Hargett St	Yes (HF)		Bus (2024)	HF			
Salisbury St	Hargett St	MLK Jr Blvd	Yes (HF)		Bus (2024)	Bus			
South St	Florence St	Wilmington St	Yes		HF (2027)	Bus			
FALLS OF NEUSE RD									
Falls of Neuse Rd	Old Wake Forest Rd	Strickland Rd	Yes		Bus (2024)	Bus	Yes		
Falls of Neuse Rd	Strickland Rd	I-540	Yes		Bus (2027)	Bus	Yes		
Falls of Neuse Rd	I-540	Durant Rd	Yes		Bus (2027)	Bus	Yes		U-5826
Falls of Neuse Rd	Durant Rd	Neuse River	Yes		Bus (2027)	Bus		Falls of Neuse Area Plan Update	
GLASCOCK ST									
Boundary St	Person St	Watauga St		HF	HF (2027)	HF			
Brookside Dr	Watauga St	Glascock St		HF	HF (2027)	HF			
Glascock St	Wake Forest Rd	Brookside Dr	Yes		Bus (2024)				
Glascock St	Brookside Dr	Chatham Lane	Yes	HF	HF (2027)	HF			

CORRIDOR/SUBAREA									
Segment	From	To	Existing Transit Service (HF = High Frequency)	Wake Transit Plan (BRT, HF)	Wake Bus Plan (HF, Bus = fixed route transit)	MTP 2045 Long Range Plan (BRT, HF, Bus)	Other transit plan (pre-WTP)	Corridor/ Sub-Area Study	NCDOT STIP
Milburnie Rd	Chatham Ln	New Bern Ave		HF	HF (2027)	HF			
GLENWOOD AVE/US 70 WEST									
Glenwood Ave	Morgan	Peace St	Yes (HF)	HF		HF			
Glenwood Ave	Peace St	Wade Ave	Yes	HF		HF			
Glenwood Ave	Wade Ave	Whitaker Mill Rd	Yes	HF	HF (2024)	HF	Yes		
Glenwood Ave	Whitaker Mill Rd	Blue Ridge Rd	Yes	HF	HF (2024)	HF	Yes		
Glenwood Ave	Blue Ridge Rd	Creedmoor Rd	Yes		HF (2024)	HF	Yes		
Glenwood Ave	Creedmoor Rd	Hillburn Dr	Yes		Bus (2024)	Bus	Yes		
Glenwood Ave	Hillburn Dr	I-540	Yes		Bus (2024)	Bus			U-2823
GORMAN AVE/AVENT FERRY RD									
Avent Ferry Rd	Tryon Rd	Athens Dr						Avent Ferry Rd Corridor Study	
Avent Ferry Rd	Athens Dr	Gorman Ave	Yes		Bus (2027)	Bus			
Avent Ferry Rd	Gorman Ave	Western Blvd	Yes		HF (2027)	HF	Yes		
Gorman Ave	Tryon Rd	Thistledown Dr					Yes		
Gorman Ave	Thistledown Dr	Avent Ferry Rd	Yes		HF (2027)	Bus	Yes		
Gorman Ave	Avent Ferry Rd	Marcom St	Yes		Bus (2024)	Bus			
Gorman Ave	Marcom St	Western Blvd	Yes		Bus (2024)	HF			
Gorman Ave	Western Blvd	Sullivan Dr	Yes		Bus (2024)	HF			
Gorman Ave	Sullivan Dr	Hillsborough St	Yes		Bus (2024)	Bus			
Crossroads Blvd	Caitboo Ave	Jones Franklin Rd	Yes				Yes		
Dillard Dr	Walnut St	Tryon Rd				Bus	Yes		
Lineberry Dr	Trailwood Hills Dr	Trailwood Dr	Yes		HF (2027)	Bus			
Trailwood Dr	Thistledown Dr	Tryon Rd	Yes		HF (2027)	Bus			

CORRIDOR/SUBAREA									
Segment	From	To	Existing Transit Service (HF = High Frequency)	Wake Transit Plan (BRT, HF)	Wake Bus Plan (HF, Bus = fixed route transit)	MTP 2045 Long Range Plan (BRT, HF, Bus)	Other transit plan (pre-WTP)	Corridor/ Sub-Area Study	NCDOT STIP
Trailwood Hills Dr	Tryon Rd	Lineberry Dr	Yes		HF (2027)				
Tryon Rd	Trailwood Dr	Trailwood Hills Dr	Yes		HF (2027)				
Tryon Rd	Dillard Dr	Gorman Ave					Yes		
HARRISON AVE/NORTH CARY BRT CORRIDOR									
Harrison Ave	I-40	Ne Maynard Rd	Yes		Bus (2024)	BRT			
Harrison Ave	Ne Maynard Rd	Chatham St	Yes		Bus (2024)	BRT			
Harrison Ave	Chatham St	Dry Ave				BRT			
HILLSBOROUGH ST									
Hillsborough St	Jones Franklin Rd	Blue Ridge Rd			HF (2024)	HF	Yes		
Hillsborough St	Blue Ridge Rd	Shepherd St	Yes	HF	HF (2024)	HF	Yes		
Hillsborough St	Shepherd St	Glenwood Ave	Yes	HF	HF (2024)	HF	Yes		
Hillsborough St	Glenwood Ave	Salisbury St	Yes	HF	Bus (2024)	HF	Yes		
KILDAIRE FARM/SOUTH CARY BRT CORRIDOR									
Kildaire Farm Rd	Dowell Dr	SW Cary Pkwy	Yes		Bus (2024)	BRT			
Kildaire Farm Rd	SW Cary Pkwy	Tryon Rd	Yes		Bus (2024)	BRT			
Tryon Rd	Kildaire Farm Rd	Regency Pkwy	Yes		Bus (2024)	BRT			
Regency Pkwy	Ederlee Dr	Tryon Rd				BRT			
LAKE WHEELER RD									
Lake Wheeler Rd	I-40	Tryon Rd	Yes		Bus (2024)			Lake Wheeler Rd Cor. Study	
MLK JR BLVD/POOLE RD									
Martin Luther King Jr. Blvd	McDowell St	Poole Rd	Yes (HF)	HF	HF (2024)	HF			

CORRIDOR/SUBAREA									
Segment	From	To	Existing Transit Service (HF = High Frequency)	Wake Transit Plan (BRT, HF)	Wake Bus Plan (HF, Bus = fixed route transit)	MTP 2045 Long Range Plan (BRT, HF, Bus)	Other transit plan (pre-WTP)	Corridor/ Sub-Area Study	NCDOT STIP
Poole Rd	Martin Luther King Jr. Blvd	Sunnybrook Rd	Yes	HF	HF (2024)	HF			
NC 42									
N42	Glen Laurel Rd	Buffaloe Rd							R-3825B
NC 50									
NC 50	Glenwood Ave	I-540	Yes		Bus (2024)	Bus	Yes		
NC 50	I-540	NC 56						NC 50 Cor. Study	
NC 55									
NC 55	US 401	Triangle Expressway				Bus	Yes		
NC 55	Triangle Expressway	US 64			Bus (Yes)	Bus	Yes		U2901B
NC 55	US 64	Durham County Line	Yes		Bus (2024)	Bus	Yes		
NC 56									
NC 56	33rd St	Darden Dr						NC 56 Cor. Study	
NC 98									
NC 98	Franklin St	US 401						NC 98 Corridor Study	
NC 98	Old Falls of Neuse Rd	Franklin St	Yes		Bus (2024)	Bus			
NC 98	US 1 Alt | Main St	Durham County Line					Yes		
NCSU AREA									
Centennial Parkway	Avent Ferry Rd	Oval Dr				HF			

CORRIDOR/SUBAREA									
Segment	**From**	**To**	**Existing Transit Service (HF = High Frequency)**	**Wake Transit Plan (BRT, HF)**	**Wake Bus Plan (HF, Bus = fixed route transit)**	**MTP 2045 Long Range Plan (BRT, HF, Bus)**	**Other transit plan (pre-WTP)**	**Corridor/ Sub-Area Study**	**NCDOT STIP**
Dan Allen Dr/Fraternity Ct	Varsity Dr	Hillsborough St				HF			
Jackson St/Wolf Village Way	Method Rd	Varsity Dr				HF			
Ligon St/Sullivan Dr	Method Rd	Dan Allen Dr				HF			
Oval Rd/Bilyeu St/Pullen Rd	NCSU	Western Blvd		HF	HF (2024)	HF			
Pullen Rd	Hillsborough St	Western Blvd	Yes	HF	HF (2024)	HF			
Varsity Dr	Sullivan Dr	Partners Way				HF			
NEW BERN AVE									
New Bern Ave	Person St	Poole Rd	Yes (HF)		HF (2027)	BRT	Yes	New Bern Ave Cor. Study	
New Bern Ave	Poole Rd	Sunnybrook Rd	Yes (HF)	BRT	HF (2027)	BRT	Yes		
New Bern Ave	Sunnybrook Rd	New Hope Rd	Yes (HF)	HF	HF (2027)	BRT	Yes		
New Bern Ave	New Hope Rd	I-540	Yes		Bus (2024)	Bus			
Edenton St	Poole Rd	Salisbury St	Yes (HF)		HF (2027)	BRT	Yes		
Edenton St	Salisbury St	Hillsborough St	Yes		Bus (2024)	HF			
Corporation Pkwy	New Bern Ave	New Hope Rd	Yes (HF)		HF (2027)	Bus			
New Hope Rd	Corporation Pkwy	New Bern Ave	Yes (HF)		HF (2027)	Bus			
NORTH HILLS/MIDTOWN									
Dartmouth Rd	Six Forks Rd	Converse Dr				BRT			
Hardimont Rd	Converse Dr	Wake Forest Rd	Yes (HF)		Bus (2024)	HF			
Lassiter Mill Rd	Scotland St	Six Forks Rd	Yes	HF	HF (2024)	HF			
North Brook Dr	North Hills Dr	Six Forks Rd		HF	HF (2027)	HF			
North Hills Dr	Lead Mine Rd	North Brook Dr		HF	HF (2027)	HF			

CORRIDOR/SUBAREA									
Segment	**From**	**To**	**Existing Transit Service (HF = High Frequency)**	**Wake Transit Plan (BRT, HF)**	**Wake Bus Plan (HF, Bus = fixed route transit)**	**MTP 2045 Long Range Plan (BRT, HF, Bus)**	**Other transit plan (pre-WTP)**	**Corridor/ Sub-Area Study**	**NCDOT STIP**
St Albans Dr	Dartmouth Rd	Hardimont Rd	Yes	HF	HF (2027)	BRT			
St Albans Dr	Hardimont Rd	Wake Forest Rd		HF	HF (2027)	BRT			
NORTHEAST CONNECTIONS – MIDTOWN TO NEW BERN AVE									
Brentwood Rd	New Hope Church Rd	Noblin Rd		HF					
Bush St	Wolfpack Lane	St Albans Dr			HF (2027)				
Highwoods Blvd	Atlantic Ave	Capital Blvd			HF (2027)	HF			
Lake Woodard Dr	Brentwood Rd	Trawick Rd	Yes (HF)		HF (2027)				
New Hope Church Rd	Wake Forest Rd	Brentwood Rd	Yes (HF)	HF	Bus (2024)	HF			
Raleigh Blvd	Brentwood Rd	Yonkers Rd	Yes	HF	Bus (2027)	HF			
St Albans Dr	Wake Forest Rd	New Hope Church Rd		HF	HF (2027)	HF			
Westinghouse Blvd	Capital Blvd	Raleigh Blvd			HF (2027)	HF			
Wolfpack Lane	Bush St	Atlantic Ave			HF (2027)				
Yonkers Rd	Raleigh Blvd	New Bern Ave		HF		HF			
RDU/MORRISVILLE									
NC 54	Harrison Ave	McCrimmon Pkwy			Bus (2024)	BRT			
NC 54	McCrimmon Pkwy	Durham County Line			Bus (Partial)	BRT			U-5750
Aviation Pkwy	NC 54	I-40							U-5811
Davis Dr	US 64	Durham County Line					Yes		
SAUNDERS ST									
Saunders St	Lenoir St	Prospect Ave	Yes		Bus (2024)	Bus			

CORRIDOR/SUBAREA									
Segment	**From**	**To**	**Existing Transit Service (HF = High Frequency)**	**Wake Transit Plan (BRT, HF)**	**Wake Bus Plan (HF, Bus = fixed route transit)**	**MTP 2045 Long Range Plan (BRT, HF, Bus)**	**Other transit plan (pre-WTP)**	**Corridor/ Sub-Area Study**	**NCDOT STIP**
Saunders St	Prospect Ave	Pecan Rd	Yes (HF)		HF (2024)	Bus	Yes	Southern Gateway Study	
McDowell St	Prospect Ave	MLK Jr Blvd	Yes (HF)		HF (2024)	Bus	Yes		
SIX FORKS RD									
Six Forks Rd (New Location)	Capital Blvd	Atlantic Ave				HF			
Six Forks Rd	Atlantic Ave	Wake Forest Rd		HF	HF (2024)	HF			
Six Forks Rd	Wake Forest Rd	Lassiter Mill Rd	Yes	HF	HF (2024)	HF	Yes		
Six Forks Rd	Lassiter Mill Rd	North Brook Dr	Yes	HF	HF (2027)	HF	Yes	Six Forks Rd Cor. Study	
Six Forks Rd	Northbrook Rd	Shelley Rd	Yes		Bus (2024)	HF	Yes		
Six Forks Rd	Shelley Rd	Lynn Rd	Yes		Bus (2024)	Bus	Yes		
Six Forks Rd	Lynn Rd	Strickland Rd	Yes		Bus (2024)	Bus	Yes		
SOUTH RALEIGH									
Rock quarry	Lenoir St	Battle Bridge Rd			Bus (2027)	Bus	Yes		
Sanderford Rd	Seabrook Rd	Rock Quarry Rd	Yes	HF	HF (2024)	HF			
State St	Lenoir St	Hadley Rd	Yes	HF	HF (2024)	HF			
US 64 WEST									
US 64	Salem St	US 1	Yes			Bus			U-5301
US 70 EAST/GARNER									
US 70	US 401	Lombard St				BRT			
US 401 NORTH									
US 401	NC 56	Flat Rock Church Rd							R-2814C

CORRIDOR/SUBAREA									
Segment	**From**	**To**	**Existing Transit Service (HF = High Frequency)**	**Wake Transit Plan (BRT, HF)**	**Wake Bus Plan (HF, Bus = fixed route transit)**	**MTP 2045 Long Range Plan (BRT, HF, Bus)**	**Other transit plan (pre-WTP)**	**Corridor/ Sub-Area Study**	**NCDOT STIP**
WAKE FOREST RD									
Wake Forest Rd	Delway St	Automotive Way	Yes (HF)		HF (2024)	Bus		Blount St-Person St Corridor Study	
Wake Forest Rd	Capital Blvd	Whitaker Mill Rd				BRT	Yes		
Wake Forest Rd	Whitaker Mill	McNeil St	Yes			BRT	Yes		
Wake Forest Rd	McNeil St	St Albans Dr	Yes		Bus (2024)	BRT	Yes		
Wake Forest Rd	St Albans	Hardimont Rd	Yes		Bus (2024)	HF	Yes		
Wake Forest Rd	Hardimont Rd	Old Wake Forest Rd	Yes		Bus (2024)	Bus	Yes		
WAKEMED AREA									
Sunnybrook Rd	New Bern Ave	Poole Rd	Yes	HF	HF (2024)	HF			
Calumet Dr	Sunnybrook Rd	Holston Ln	Yes		HF (2024)	HF			
WESTERN BLVD									
Western Blvd	Jones Franklin Rd	Blue Ridge Rd	Yes	BRT	HF (2024)	BRT			
Western Blvd	Blue Ridge Rd	Pullen Rd	Yes	BRT	HF (2027)	BRT			
Western Blvd	Pullen Rd	Mc Dowell St	Yes	BRT	HF (2027)	BRT			
WILMINGTON ST/US 401 SOUTH									
Wilmington St	Peace St	Morgan	Yes (HF)	BRT	HF (2024)	HF			
Wilmington St	Morgan	MLK Jr Blvd	Yes (HF)	BRT	HF (2027)	HF			
Wilmington St	MLK Jr Blvd	Pecan Rd		BRT	HF (2027)	BRT		Southern Gateway Study	
Wilmington St	Pecan Rd	Tryon Rd	Yes (HF)	BRT	HF (2024)	BRT	Yes		
US 401	Tryon Rd	Ten Ten Rd	Yes		Bus (Yes)	Bus	Yes		U-5980
US 401	Ten Ten Rd	Judd Pkwy	Yes		Bus (Yes)	Bus	Yes		

Report 3: Existing Conditions Report

RED LANES EXISTING CONDITIONS

INTRODUCTION AND SUMMARY OF CONTENTS

PURPOSE OF REPORT

The Capital Area Metropolitan Planning Organization (CAMPO) RED Lanes Study is taking a comprehensive look at transit priority lanes as a potential part of the region's approach to enhancing its transportation system to meet growing demand, improve transit operations, and diversify modal options for local and regional travel. RED lanes are sometimes referred to as business access and transit (BAT) lanes or transit priority lanes. Transit priority lanes are an increasingly common component of regional transportation planning and transit investment across the U.S. and around the world. They can be a cost-effective solution for improving transit operations and service reliability.

Figure 1. The ECR is the last step before developing the evaluation methodology and scoring tool for candidate RED lanes.

Two previous reports – *RED Lanes Fundamentals* and *Key Plans in the CAMPO Region* – defined key concepts and components of RED Lanes and highlighted prior regional planning efforts related to RED Lanes implementation, respectively. This *Existing Conditions Report* (ECR) examines existing conditions and trends across a variety of indicators to provide insight into where RED Lanes are likely to be most appropriate. The ECR builds on the findings of the previous reports, relating key indicators to best planning practices for RED lanes and grounding indicator development in relevant past or ongoing planning efforts. The data and maps developed for this report will inform later phases of the CAMPO RED Lanes Study, including the development of a RED lanes evaluation/prioritization methodology for ranking corridors in the CAMPO region according to their suitability/readiness for RED lane implementation. Therefore, the ECR functions both as a snapshot of regional trends and conditions affecting transit system performance and regional mobility as well as a foundational component of the RED Lanes evaluation methodology.

REPORT STRUCTURE

The ECR is organized into four major sections. The first section ("Key Findings") summarizes key findings from the development and analysis of key indicators and metrics describing the performance of the regional transportation system, planned transit operations, facility contexts, and policy considerations. These findings offer general guidance for developing the RED Lanes evaluation methodology in the next phase of the RED Lanes Study.

The second section of the ECR ("Indicators and Metrics") provides detailed analyses of specific indicators and metrics, offering maps and detailed insight beyond the high-level conclusions reported in the "Key Findings" section. Many of the metrics reported in this section will comprise the data to be incorporated into the RED Lanes evaluation methodology. Therefore, this section also outlines the key data sources required to reproduce metrics. For some indicators, potential alternative metrics, data sources, and/or analysis approaches are described for consideration in potential future applications of or updates to the RED Lanes evaluation methodology.

The "Indicators and Metrics" section is organized into major topic areas based on the RED Lanes Information Gathering Concept Matrix.[1] The ECR focuses primarily on the "Demand," "Operations," and "Contexts" topic areas as these are the most directly applicable to the evaluation and ranking of corridors for potential RED Lanes implementation. For example, corridors may be substantially differentiated based on transit ridership (demand), transit service frequency (operations), and service to disadvantaged population groups (contexts).

Indicators and metrics under the "Design" and "Other Considerations" headings are addressed in this report on an "as available and applicable" basis. These topics are primarily expected to inform how a RED Lane project should be designed and implemented and have limited applicability to corridor evaluation and prioritization. For example, while design considerations are important to the successful deployment of RED lanes, existing roadway design does not necessarily impact a corridor's suitability for future RED lane implementation since the design may be changed as part of the implementation. However, RED Lanes may be difficult to implement on roadways where right-of-way constraints pose challenges to a redesign. For this reason, this report includes a planning-level analysis of available right-of-way to offer a coarse assessment of RED Lane feasibility within a given corridor.

Likewise, indicators within the "Other Considerations" topic area address key considerations for RED Lanes implementation and are not expected to directly inform the prioritization methodology for potential RED lane corridors. For example, RED Lanes are not intended primarily as safety improvements, and it would be inappropriate to prioritize RED Lanes based on existing safety data. Rather, safety is a key consideration in implementation, affecting design and amenities decisions for a given RED Lane project. For appropriate incorporation of the "Design" and "Other Considerations" topic areas in a particular RED Lane project, a review of the *RED Lanes Fundamentals* report is recommended, as design concepts, service characteristics, and best planning practices are described in that document.

The Information Gathering Concept Matrix is re-printed in Figure 2 below as a reminder of the major topic areas associated with RED Lanes planning and implementation.

The third section of the ECR ("Inventory of Data and Tools") provides an inventory of data sources and analysis tools used to create the indicators and metrics presented in the previous section. The

[1] The *RED Lanes Fundamentals* report introduced the RED Lanes Information Gathering Concept Matrix as a simple and consistent framework for organizing and summarizing best practices, case studies, and literature review findings related to RED Lanes. It was also used in the *Key Plans in the CAMPO Region* report to summarize and interpret prior planning documents related to RED Lanes and transit priority treatments.

documentation of data sources is important to ensure the RED Lanes evaluation methodology can be reliably replicated by compiling and processing the same body of data used in this initial study.

Finally, the ECR closes by identifying potential corridors to add to the Candidate Corridors list and map developed in the *Key Plans in the CAMPO Region* report, based on ECR findings.

<table>
<tr><th colspan="3">RED LANES INFORMATION GATHERING CONCEPT MATRIX</th></tr>
<tr><th>Topic Area</th><th>Indicator</th><th>Findings</th></tr>
<tr><td rowspan="5">Demand
(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)</td><td>Transit Ridership</td><td rowspan="5">Demand indicators are generally greatest in downtown Raleigh and other locations within the Beltline.</td></tr>
<tr><td>Transit Mode Share</td></tr>
<tr><td>Traffic Volume</td></tr>
<tr><td>Non-Motorized Users</td></tr>
<tr><td>Person Throughput</td></tr>
<tr><td rowspan="6">Operations
(Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)</td><td>Transit On-Time Performance</td><td rowspan="6">Operations indicators describe a variety of opportunities to enhance transit services that are spread throughout the more densely developed portions of the region. These indicators also highlight corridors with mobility constraints.</td></tr>
<tr><td>Transit Reliability (Route Travel Time)</td></tr>
<tr><td>Transit Service Frequency</td></tr>
<tr><td>Transit Signal Priority</td></tr>
<tr><td>Person/Vehicle Delay</td></tr>
<tr><td>Average Travel Speeds</td></tr>
<tr><td rowspan="5">Contexts
(Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)</td><td>Adjacent Land Uses</td><td rowspan="5">Context indicators demonstrate a wide variation across the region, contrasting the characteristics of transit-supportive development patterns generally oriented toward regional activity centers, transit-dependent populations dispersed throughout the region (with a southeasterly focus typical of eastern seaboard fall line cities) and a latticework of potential network connections.</td></tr>
<tr><td>Context Classification/ Complete Streets</td></tr>
<tr><td>Parking/Curb space</td></tr>
<tr><td>Accessibility</td></tr>
<tr><td>Facility Functional/Access Class</td></tr>
<tr><td rowspan="4">Design
(Available ROW, shared modes/ movements)</td><td>Number of Lanes</td><td rowspan="4">Certain design indicators including multiple travel lanes and wide building setbacks help identify regional opportunities. Most indicators are dependent on design strategies addressed at a project level.</td></tr>
<tr><td>Lane Width</td></tr>
<tr><td>Intersection Design</td></tr>
<tr><td>Separation of Traffic</td></tr>
<tr><td rowspan="5">Other</td><td>Safety</td><td rowspan="5">Safety, enforcement, maintenance, cost, and project length to be addressed at a project level, following best practices findings from RED Lanes Fundamentals report.</td></tr>
<tr><td>Enforcement</td></tr>
<tr><td>Maintenance</td></tr>
<tr><td>Cost</td></tr>
<tr><td>Project length</td></tr>
</table>

Figure 2. The Information Gathering Concept Matrix organizes the findings of the ECR.

KEY FINDINGS

This section summarizes the key findings of the Existing Conditions Report, with a focus on highlighting broad trends revealed by the analyses presented in the “Indicators and Metrics” section and relating them to the RED Lanes evaluation methodology. Broadly, the analysis of indicators generated intuitive findings with respect to the general areas within the CAMPO region where transit demand, operations, context, and design factors are most supportive of RED Lanes and related improvements. However, it also highlighted how data availability, metric definitions, and analysis outputs affect the prospective use and interpretation of each indicator in the RED Lanes evaluation methodology, including the emphasis placed on each indicator in corridor prioritization.

Across all indicators and metrics, there is a **general confluence of RED Lanes suitability factors inside the I-540/NC-540 loop**. This includes the southeastern portions of the region around Garner, but is mostly concentrated on Cary, North Raleigh, and the Inside the Beltline communities within I-440. Isolated suitability for RED Lanes may be found in other parts of the region, but these are expected to be few and highly localized exceptions.

The ECR analysis revealed that some indicators are best suited to application in the RED Lanes **prioritization** process for determining which corridors in the region offer the best conditions for successful RED Lanes, while other indicators provide information that can help **guide appropriate development** of a RED Lane project within a particular corridor. Indicators with strong supporting data, clear metric definitions, and direct relationships to the policy goals that RED Lanes address are ideally suited for use in the prioritization process. Indicators for which data are sparse, metric definitions are imprecise, and/or analysis results relate more clearly to implementation approaches are better suited for guiding RED Lane project development. For example, forecasts of transit ridership can be used to prioritize high ridership corridors; analysis of ridership by time of day can be used to determine whether a RED Lane project should consider part-time or full-time lane restrictions. Based on the analysis provided here, part time restrictions are likely to be more appropriate on major commuting corridors, such as US 1, US 401 and NC 55. Full-time RED Lanes would be more appropriate on in-town corridors such as Oberlin Road, Raleigh Boulevard, and State Street. Policy considerations – such as complete streets and parking/curb space management – are difficult to operationalize for prioritization purposes and are better suited to guide implementation.

For many indicators and metrics, **accounting for directionality will be important**. RED Lanes are generally expected to be bi-directional symmetric improvements, providing priority bus treatments in both directions along a segment. For corridors with imbalanced peak hour/peak directional flows, bi-directional RED Lanes may be a sub-optimal use of the right-of-way, at least on a full-time basis. Top priority corridors will, ideally, have balanced directional flows throughout the day. Throughout the ECR, peak period metrics are reported for the PM period since more trips occur during the afternoon peak than any other travel period on a regional basis. When considering the impact of directionality on RED Lane design approaches, both the AM and PM period should be considered for the specific corridor.

Many of the region’s **Communities of Concern (CofC’s) are difficult to serve with transit**. CofC’s are areas that contain concentrations of one or more population groups identified in CAMPO’s Title VI, Minority, Limited English Proficiency (LEP), and Low Income Public Outreach Plan. CofC’s that are inside the I-540/NC-540 loop generally are served by transit that provides moderate-to-high access to jobs. However, the majority of CofC's are in outlying communities that are only partially served by express services. RED Lanes benefits to these communities will likely be best achieved through the implementation of part-time RED Lanes at key delay points on commuting routes. However, since RED Lanes focus on enhancing travel speed and reliability on segments with frequent transit service, they are unlikely to significantly improve transit access for currently underserved communities.

Finally, the development of the ECR has revealed that the creation of a robust RED Lanes evaluation methodology will require reliable methods of relating spatial datasets from different sources to a **single authoritative dataset** that represents streets for consideration as RED Lanes corridors. Many of the datasets used to generate the measures produced for this ECR are developed independently such that, although features may be near one another, it is often difficult to relate them accurately to one another. This means combining and comparing metrics from one dataset with those in another dataset requires line conflation analyses. As an example, transit route lines may be generated by a transit agency, while highway features are obtained from the Triangle Regional Model. To analyze transit ridership and traffic volumes by segment, each route feature must be related to the highway segments on which the route operates. In establishing relationships among features it is important to ensure that unrelated features are not erroneously included. Common algorithms for determining spatial relationships, such as buffers, intersects, and spatial joins, are helpful but limited. Effective line conflation is likely to require automation of various spatial analysis routines as well as manual quality assurance checks.

Indicators and Metrics

This section presents key indicators and metrics expected to be useful in evaluating candidate corridors for potential RED Lane implementation. For many indicators, forecastable trends are addressed instead of existing conditions to allow the RED Lanes evaluation methodology to account for future conditions. Indicators and metrics reported in this section are organized according to the major topic areas in the Information Gathering Concept Matrix as described in the introduction to this report.

In this report, a topic area refers to a collection of considerations that inform RED Lanes prioritization and planning. An indicator is a conceptual dimension of a topic area. For example, transit service frequency and transit on time performance are both dimensions of the operations topic area. To adequately and holistically account for operations issues in the RED Lanes Study, these and similar indicators must be examined. To this end, metrics are the specific measurements used to quantify and compare segments across various indicators. Continuing the previous example, transit service frequency is an easy to understand concept, but it needs to be measured and reported with clearly defined units, such as number of transit trips per hour, to be applicable in the RED Lanes evaluation methodology.

The RED Lanes Study Core Technical Team (CTT) provided guidance during Workshop #1 (March 5, 2019) regarding the relative importance of each indicator for inclusion in the Existing Conditions Report. The CTT also offered suggestions for aspects of a given indicator to emphasize for analysis. For example, the CTT suggested the transit service frequency topic area should focus on planned service frequency rather than existing frequency. In the subsections devoted to each indicator below, the CTT's input is summarized in a small call-out box, conveying what specific aspects of an indicator would ideally be examined and what the indicator's relative priority (High, medium, or low) in the RED Lanes evaluation methodology should be. It is important to note that the final determination of each indicator's priority in the RED Lanes evaluation methodology will ultimately be settled in subsequent phases of the RED Lanes Study. For a small number of indicators, analytical limitations such as a lack of regionally available data or methodological complexity sometimes prevented specific preferred aspects from being examined. For example, the CTT indicated an interest in peak-hour on-time performance for transit routes. However, the regional transit providers routinely track on-time performance on a daily basis. When these analytical limitations apply, they are noted in the text in each indicator's sub-section, often in the "other notes" unit.

Each indicator is introduced by defining what aspect(s) of transportation system analysis it describes (What is it?) and explaining the its relationship to RED Lanes planning and analysis (Why does it matter?). The details of metrics used to operationalize the indicators (How is it measured?) are then presented, followed by a discussion of the data sources and tools used to generate the measures (What data and tools are needed?). In most cases, maps of measures and a brief discussion of findings is then offered. Each indicator's sub-section closes with notes, if any, on additional research needs or potential future enhancements to guide the maturation of the RED Lanes evaluation approach over time as data sources and analytical capabilities evolve.

Table 1 provides an overview of the indicators included in the ECR report by topic area with notes on their suggested priority in the RED Lanes evaluation methodology based on CTT input as well as from the literature review conducted for the RED Lane Fundamentals report. The table also indicates whether a metric represents existing or future conditions.

Table 1 RED Lanes Indicators and Metrics at a Glance

TOPIC AREA Indicator	Metric	CTT Priority	Literature Priority
DEMAND			
Transit Ridership (p. 9)	Forecasted daily route-level transit passengers by segment in 2045	High	High
	Forecasted peak-hour route-level ridership as a share of daily route-level ridership by segment in 2045	High	High
Transit Mode Share (p. 13)	Transit commute (journey to work) mode share in 2015	Low	Low
Traffic Volume (p. 15)	Forecasted daily bi-directional traffic volume by segment in 2045	Low	High
	Forecasted PM peak hour volume-to-capacity ratio by direction in 2045	Low	Medium
Non-motorized Users (p. 19)	Walk access to jobs (proxy for non-motorized trip demand) in 2014	Low	Low
Person throughput (p. 21)	*To be addressed at a project level*	*High*	*High*
OPERATIONS			
Transit on time performance/reliability (p. 22)	On time performance rates by route in 2018/19	High	High
Transit service frequency (p. 26)	Transit vehicles per hour (bi-directional) by segment in 2019	Low	High
	Future RED Lanes-supportive frequency by segment by planning horizon year.	Low	High
Transit Signal Priority (p. 30)	*To be addressed at a project level*	*Medium*	*NA*
Person/vehicle delay (p. 31)	Forecasted AM peak hour congested-to-free-flow-speed ratio by direction in 2045	Low	Medium
Average travel speed (p. 34)	Forecasted peak hour bus travel speed by direction in 2045	Low	Medium
CONTEXTS			
Adjacent land uses (p. 36)	Activity unit density by TAZ in 2013	Medium	Low
	Intersection density by block group in 2011	Medium	Low
Context classification/ complete streets (p. 40)	*To be addressed at a project level*	*Medium*	*NA*
Parking/curb space (p. 42)	*To be addressed at a project level*	Low	Low
Accessibility (p. 44)	Transit-to-auto access to jobs ratio in 2013	Medium	NA
	Communities of concern by block group in 2012	Medium	Low
Functional/access class (p. 48)	Functional class by segment in 2045	Low	Low
DESIGN/OTHER			
Number of lanes (p. 51)	Segment lane count by direction in 2013	Medium	Medium
	Buildings intersected (within potential ROW buffer) per mile by segment in 2018	Medium	Medium
Intersection design, separation of traffic, safety, enforcement, maintenance, cost, and project length to be addressed at a project level, following best practices findings from RED Lanes Fundamentals *report.*			

DEMAND

- Transit Ridership
- Transit Mode Share
- Traffic Volume
- Non-Motorized Users

TOPIC | DEMAND

Travel demand considerations are important determinants of suitability for RED Lanes. Ideally, RED Lanes will be implemented to benefit the greatest number of travelers, and demand indicators support the identification of the region's busiest corridors. This section highlights existing conditions and forecasted trends for travel demand by mode; it also points out key findings for each indicator for consideration in developing the RED Lanes evaluation methodology.

INDICATOR | TRANSIT RIDERSHIP

What is it? Transit ridership reports the number of passengers using current transit services or the forecasted utilization of future services. Ridership can be reported on a systemwide, route, or street-segment level (route level or finer is most appropriate for RED Lanes and other corridor-level analyses). Ridership is often highest in peak commuting periods, especially for express services and other commuter-oriented routes.

Core Technical Team input
Focus on forecasts and peak hour ridership.

Priority in evaluation methodology: High

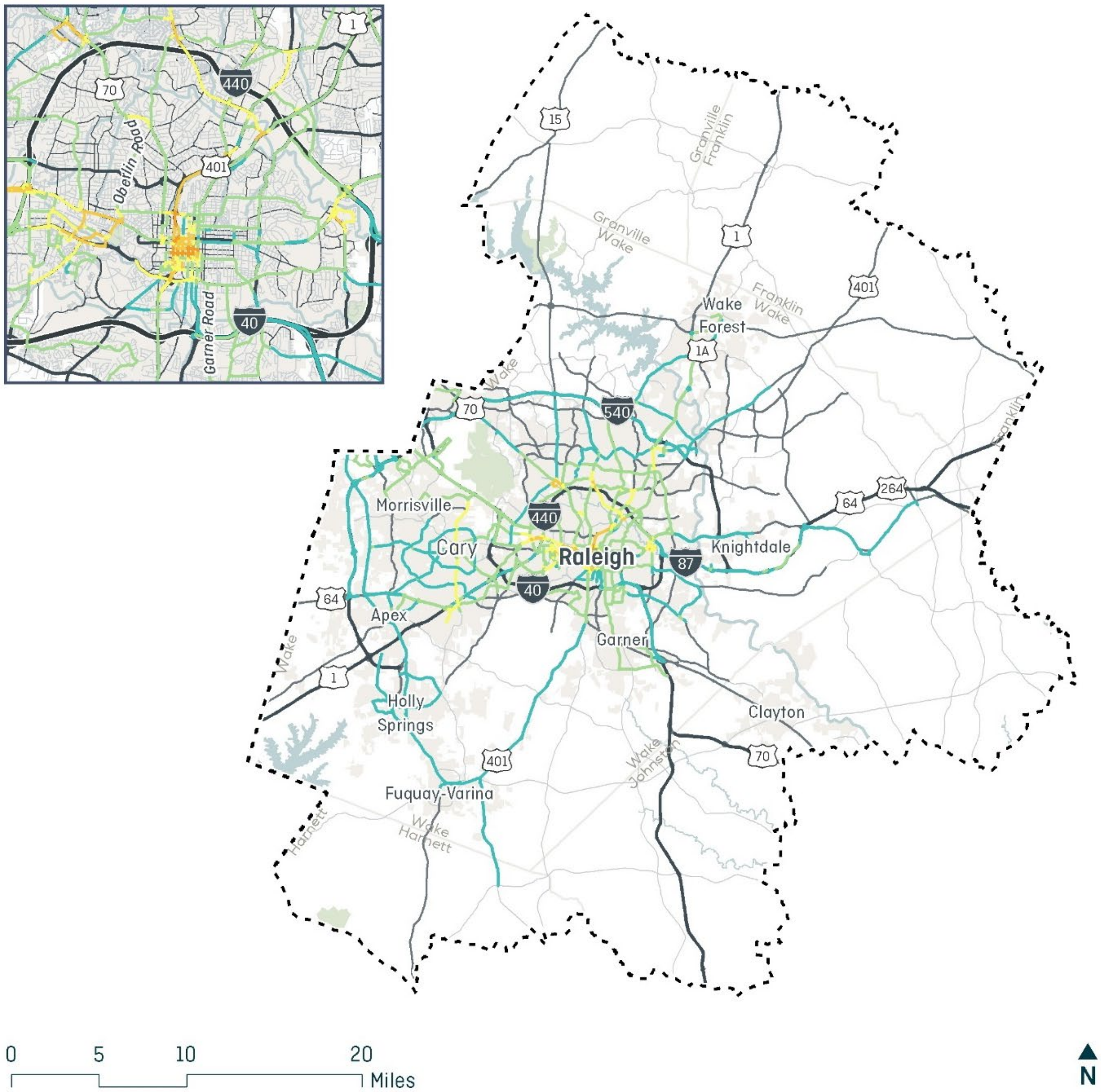
Why does it matter? RED Lanes can provide travel times savings and reliability benefits, and these are most impactful on high-ridership routes as greater numbers of passengers are benefited. There is a broad consensus in the literature that RED Lanes are most appropriate in high-ridership corridors.

How is it measured? Ridership is typically measured in units such as total passengers (on a daily or peak hour/peak period basis) or normalized by service characteristics such as passengers per revenue hour or revenue mile of service to focus on productivity. In this report, total daily passengers forecasted for the year 2045 is presented as the key ridership measure. This provides insight into which corridors are expected to carry the highest volumes of transit passengers in the intermediate- to long-term future. The share of daily passengers using transit during peak commuting periods is also reported, since this can provide useful guidance to RED Lane implementation and design considerations (full-time vs. part-time RED Lane, e.g.).

What data and tools are needed? For this report, ridership forecasts were obtained from the Triangle Regional Model (TRM) for the year 2045. The TRM provides ridership forecasts at the route level. Since multiple routes may operate within a single corridor, these route-level forecasts were aggregated at a segment level on the TRM 2045 highway network. This allows differentiation among segments where multiple routes operate. However, it is not the same as a segment level ridership forecast, which requires more detailed travel modeling. Rather, it reports the total number of riders for all routes operating on a segment. BRT and rail transit ridership data were excluded from the ridership estimates utilized in this analysis.

The consolidation of route-level ridership forecasts at the segment level was accomplished using custom geoprocessing scripts in ArcGIS. These scripts will be shared as part of the RED Lanes toolkit to be developed during a later phase of the study.

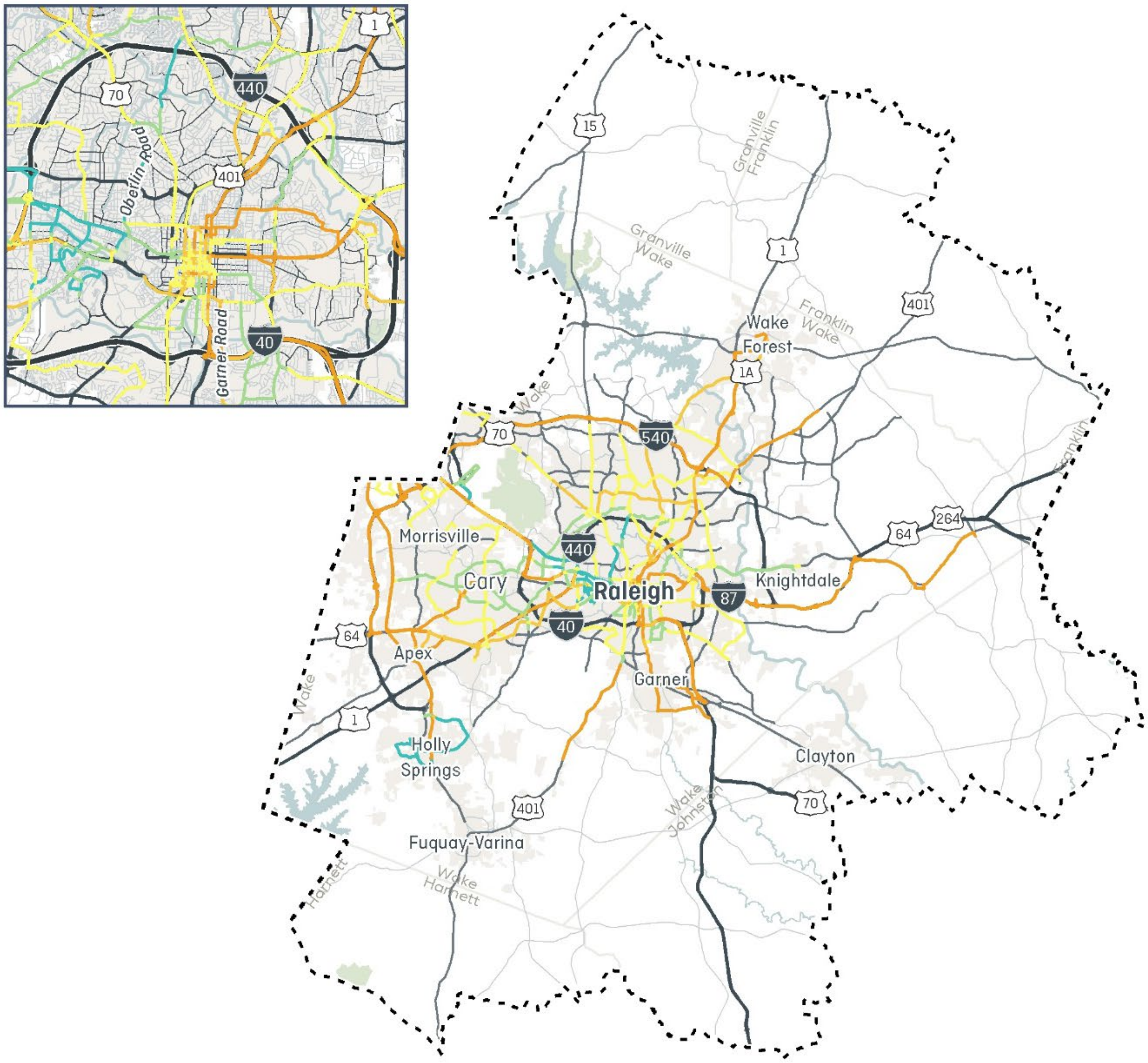
RED LANES | EXISTING CONDITIONS - TRANSIT RIDERSHIP



TRM Daily Ridership
on Routes Using Segment

- 0 - 1,000
- 1,001 - 5,000
- 5,001 - 10,000
- 10,001 - 20,000
- 20,001 - 53,251

RED LANES | EXISTING CONDITIONS - TRANSIT RIDERSHIP



0 5 10 20 Miles

N

TRM Share of Route Ridership in Peak Periods

- Up to 50%
- 50.1% - 60%
- 60.1% - 70%
- 70.1% - 80%
- More than 80%

Findings: Based on the TRM analysis, the CAMPO region's highest transit ridership areas are in Downtown Raleigh, NCSU, Crabtree/North Hills, WakeMed, Capital Boulevard, and the north-south axis through Cary (Kildaire Farm Road and Harrison Avenue). Many segments with the highest cumulative route level ridership are short, spanning only a few blocks. Corridors with extensive high ridership include Kildaire Farm/Harrison, Six Forks Road, Hillsborough Street, Western Boulevard/MLK Boulevard, and Capital Boulevard/Atlantic Avenue.

The lowest shares of peak period ridership are around the NCSU campus, west Raleigh (Oberlin Road, Blue Ridge Road, Edwards Mill Road, e.g.), and on circulator routes in Cary, Holly Springs, Knightdale, etc. For corridors with high shares of daily ridership during peak periods, part time RED Lanes may be more appropriate than full time RED Lanes.

Other notes: Detailed evaluation of transit ridership can require sophisticated and data-intensive travel modeling approaches and tools. The findings of this analysis are based on outputs already being generated by the TRM. If the TRM can readily produce segment-level ridership forecasts, these may provide better insight into the details of transit travel demand. In future applications of or updates to the RED Lanes evaluation methodology, the availability of segment-level ridership forecasts should be investigated.

Alternatively, route level ridership estimates could be disaggregated to the segment-level based on stop-level boarding and alighting data, if available from partner transit agencies, such as GoRaleigh and GoCary. Automated Passenger Counters (APCs) are often used by transit agencies to track boarding and alighting activity. These could be used for route-level ridership disaggregation. The development of a reliable regionwide disaggregation methodology may serve a variety of planning purposes beyond application in RED Lanes evaluation but would require a level of effort beyond the scope of the current study.

INDICATOR | TRANSIT MODE SHARE

Core Technical Team input
Focus on forecasts.

Priority in evaluation methodology: Low

What is it? Transit mode share describes the percentage of total trips made using a transit mode. Mode share is typically analyzed at a zonal level, evaluating all travel to or from a given area and what proportion of total trip-making is made by each mode. For example, a downtown business district may conduct a study to learn what percentage of all trips to the district are made by non-auto modes. Mode share for an area reflects the cumulative mode choices of individual travelers making trips to/from that area; these individual choices may be affected by the availability of modal options (transit service, household vehicle availability, etc.), socio-economic and demographic characteristics (family size, income, etc.), and built environment characteristics (land use diversity, network connectivity, etc.).

Why does it matter? High transit mode shares are often products of effective service design that makes transit travel times competitive with driving. In other cases, they may reflect a community's dependency on transit for trips beyond walking distance due to limited vehicle availability. RED Lanes are likely to be most effective in corridors serving areas that already utilize transit. They offer the potential to enhance transit travel times and reliability for these existing riders and boost ridership in other areas.

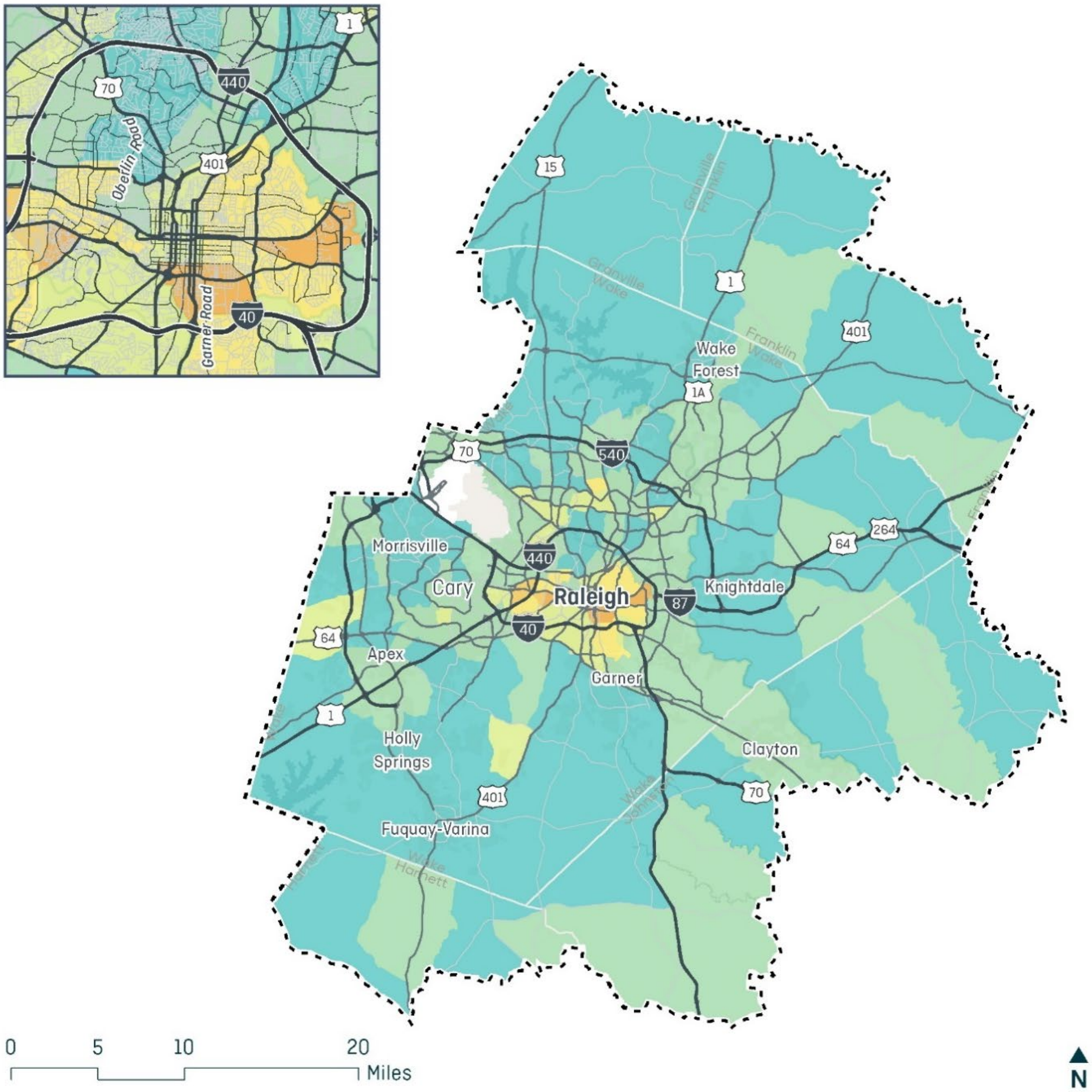
How is it measured? Transit mode share is typically reported as a percentage. For example, if an area has a mode share of five percent, it indicates that one in 20 trips generated from the area are made by transit. Mode share is typically reported for coarse zones (census block groups, census tracts, or traffic analysis zones, e.g.) that encompass many blocks. Estimating mode shares at a highly local level requires intensive travel models and/or robust local travel data to support model calibration.

What data and tools are needed? Reliable mode share estimates and forecasts are difficult to obtain. Regional travel models (like the TRM) sometimes provide insightful outputs, but the application of these models often requires calibration to local conditions (i.e. for a specific sub-area within a region) to accurately forecast mode choices, making them unsuitable for regionwide analysis. This report utilizes mode share estimates from the American Community Survey's (ACS) Journey-to-Work (JTW) 2013-2017 tables. These provide estimates of commute mode share for census geographies down to the tract level. The JTW includes working from home as a mode, but this was excluded for the analysis presented here to focus specifically on transit commutes as a share of all commute trips.

Findings: Transit commute mode shares are generally low throughout the CAMPO region, with many of the region's most populous areas making less than one percent of commutes by transit. Transit shares are highest inside the I-440 beltway and at a smattering of other locations elsewhere in the region. Locations near the region's periphery with moderate to high mode shares likely reflect park-n-rider commuters.

Other notes: Numerous current research efforts are focused on developing reliable, re-usable methods for providing fine-grained mode share estimates with reduced or no reliance on regional travel models. In some cases, these approaches lean on simple behavioral relationships – such as mode choice based on relative accessibility scores – while others utilize emerging travel data from big data vendors. Future updates to the RED Lanes evaluation methodology should explore innovative approaches to forecasting mode shares.

RED LANES | EXISTING CONDITIONS - TRANSIT COMMUTE MODE SHARE



Percent of Commutes on Transit (Work-at-Home Excluded)

- 0%
- 2% or less
- 2.1% - 5%
- 5.1% - 7.5%
- 7.6% - 10%
- Greater than 10%

INDICATOR | TRAFFIC VOLUME

Core Technical Team input
Focus on forecasts and peak hour ridership.

Priority in evaluation methodology: Medium

What is it? Traffic volume is a fundamental measure of overall travel demand, quantifying the number of vehicles on a roadway for a given time period. It is generally reported on a segment basis for an average day as well as for peak commuting periods. In many cases, volume by direction is provided. Traffic volume also provides the basis for calculating volume-to-capacity (v/c) ratios for segments. A segment's v/c ratio compares vehicle demand relative to estimated capacity, providing some insight into how congested the facility is.

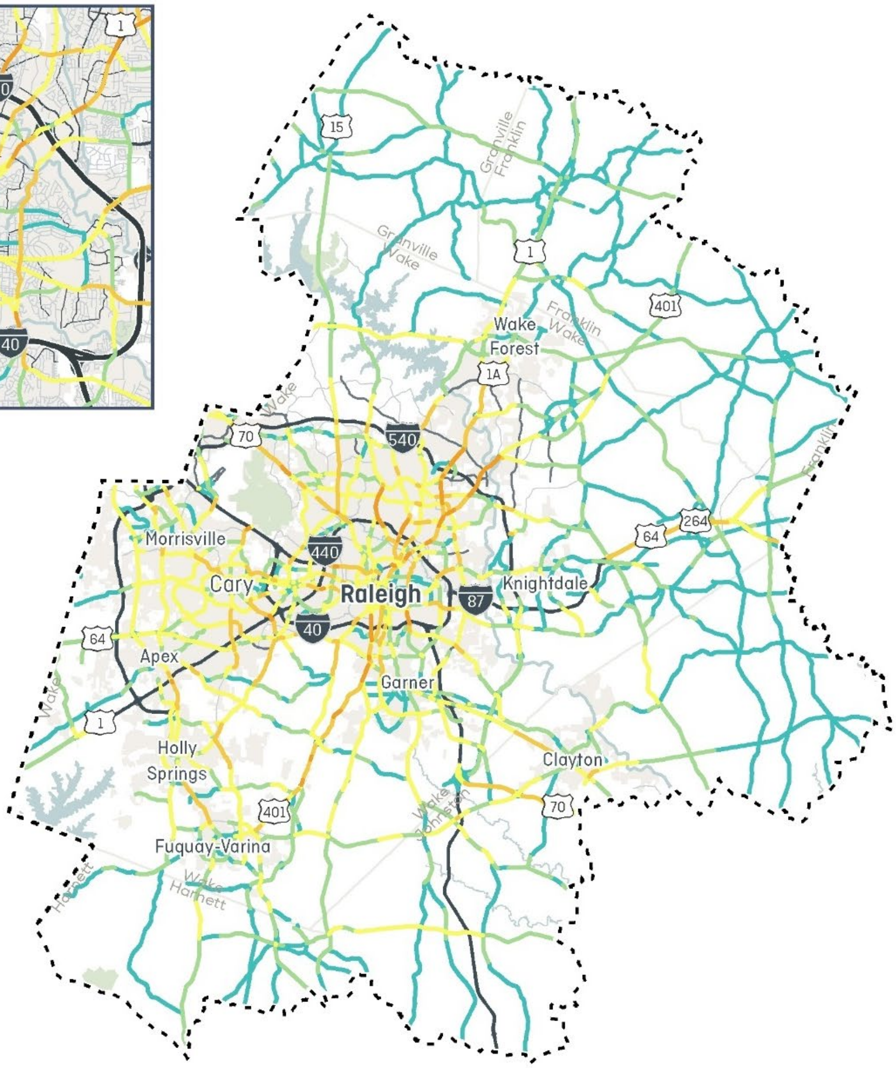
Why does it matter? RED Lanes can pose an opportunity cost in terms of reduced general use capacity for other vehicles in cases where an existing travel lane is designed as a RED lane. Traffic volumes and related measures, such as Level of Service (LOS) and volume to capacity ratios (v/c), can be used to estimate potential impacts on existing road users and to gauge the appropriateness of RED Lanes facilities. Traffic volumes can also be useful in identifying potential applications of Transit Signal Priority (TSP) or other companion strategies. The greatest RED Lanes benefits generally occur at intersections where the operational v/c is between 0.8 and 1.0. From a planning perspective, a segment v/c ratio of 1.2 is a generally equivalent and appropriate upper threshold due to the systemwide nature of long-range travel demand forecasting models such as the TRM in which operational issues like vehicle spillback are addressed implicitly rather than explicitly.

How is it measured? Absolute values of vehicles using each segment are typically reported. In this report, daily bi-directional volume forecasted for 2045 is presented first. This provides a clear sense of where the region's heaviest total travel demand is, which could heighten a corridor's suitability for RED Lanes if other considerations, such as transit service frequency and ridership are also favorable. However, a second measure – PM peak hour v/c ratio by direction for 2045 – provides additional insight into how much volumes are likely to affect roadway operations. Excessive v/c ratios (greater than 1.2) are often unsuitable for RED Lane implementation.

What data and tools are needed? TRM is the best source for developing regionwide traffic volume and v/c ratio estimates, especially for future year forecasts. Traffic volume metrics are obtained as outputs on the TRM's highway network in a readily-usable format. In this study, maps of daily traffic volumes excluded Interstate highways and other expressways or tollways, since these facilities often carry much higher volumes of traffic than surface streets and are not candidates for RED Lane implementation. PM Peak hour v/c ratios are mapped since these typically represent the time of day when traffic volumes are highest.

Findings: Volumes are highest in commuting corridors between Raleigh and suburban and exurban locations in all directions. Prominent high-volume corridors are listed in Table 2. Emerging secondary markets may be visible in southwestern Wake County (Fuquay-Varina – Holly Springs – Apex – Cary), the Research Triangle Park (RTP)/airport area, and between Clayton and Garner. In many of these major commuting corridors, the v/c map reveals a high degree of directionality. Though the ratios are generally within levels compatible with RED Lane implementation, transit priority treatments may be better suited to shorter high-volume corridors with less directional peaking, such as Kildaire Farm Road or Raleigh Boulevard.

RED LANES | EXISTING CONDITIONS - TRAFFIC VOLUME



0 5 10 20 Miles

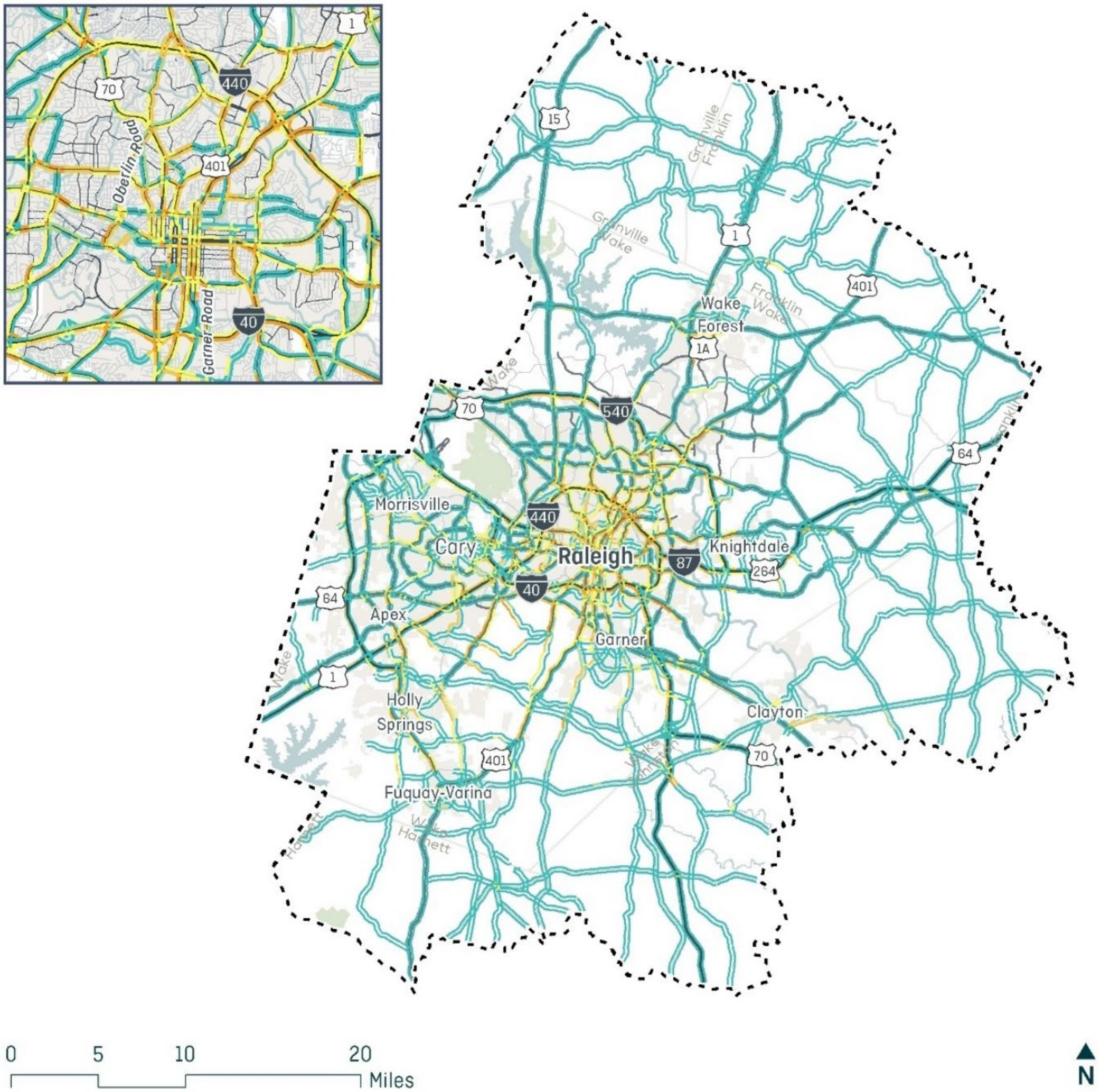
N

2045 Total daily volume (TRM)

- 0 - 10,000
- 10,001 - 20,000
- 20,001 - 40,000
- 40,001 - 60,000
- 60,001 - 123,845

Interstates and other expressways and tollways excluded.

RED LANES | EXISTING CONDITIONS - TRAFFIC VOLUME



2045 Volume-to-Capacity (v/c) ratio by direction (PM Peak Period)

- 0.00 - 0.75
- 0.76 - 0.85
- 0.86 - 1.05
- 1.06 - 1.25
- 1.26 - 2.25

Traffic Volume

DEMAND OPERATIONS CONTEXTS DESIGN

Table 2 Corridors with 2045 Daily Volumes in Excess of 50,000

Road Name	Length (mi)	Daily Volume	v/c in NB or EB dir	v/c in SB or WB dir
S. Saunders St.	1.32	81,096	1.25	1.01
Rock Quarry Rd.	0.77	69,238	1.41	1.10
Six Forks Rd.	2.34	67,646	0.92	1.08
US 401 (NORTH)	4.30	67,591	0.53	0.59
Capital Blvd.	3.94	65,803	0.70	0.99
Western Blvd.	0.17	61,413	1.61	1.43
N. Harrison Ave.	0.42	60,462	0.69	0.67
Lake Wheeler Rd.	0.24	59,744	1.63	1.16
Falls of Neuse Rd.	0.79	59,528	0.81	1.00
Wake Forest Rd.	2.03	59,225	0.98	1.19
US 401	6.99	58,107	0.90	0.62
Walnut St	1.46	56,950	0.84	0.94
Glenwood Ave.	0.32	56,802	1.08	0.49
US 70	2.32	56,606	0.56	0.81
Kildaire Farm Rd.	0.34	56,448	1.27	1.18
S.E. Maynard Road	0.09	56,261	0.99	0.86
NC 55	1.45	56,112	1.18	0.92
Creedmoor Rd.	1.13	55,672	0.73	1.02
Aviation Pkwy	0.28	55,336	0.84	0.74
Gorman St.	0.12	54,940	1.26	1.03
Wade Ave.	2.19	54,394	1.16	1.13
Sunset Lake Rd	0.40	53,389	1.43	1.06
Wilmington St.	1.41	53,180	0.62	0.51
Walnut St.	0.25	52,933	0.79	0.86
NC 54	0.20	52,011	1.19	1.00
New Hope Rd.	0.29	51,994	1.12	1.20
New Bern Ave.	0.46	51,714	0.50	0.98
Holly Springs Rd	1.47	51,505	1.19	0.91
Davis Drive	0.45	51,378	1.22	1.00
Poole Rd.	0.21	50,824	1.06	1.37
Hammond Rd.	0.39	50,302	1.01	0.66
Spring Forest Rd.	0.19	50,288	0.97	1.25
Raleigh Blvd.	0.15	50,273	1.36	1.05

Table 2 shows the corridors with daily bi-directional traffic volumes exceeding 50,000 vehicles. PM Peak period v/c ratios are also shown. In many cases, v/c ratios are in acceptable ranges for RED Lanes implementation (highlighted cells). Since the table focuses on the highest-volume facilities, it suggests that many of the most congested facilities shown in the v/c map are only carrying moderate traffic.

Other notes: (None)

INDICATOR | NON-MOTORIZED USERS

Core Technical Team input
Focus on forecasts and peak hour ridership.

Priority in evaluation methodology: Low

What is it? Non-motorized travel modes are essential components of multimodal urban transportation. The two major non-motorized modes are walking and bicycling. Demand for these modes arises for utilitarian purposes (work and shopping trips, e.g.), multimodal connectivity (access to/egress from transit, e.g.), and recreational or social activities.

Why is it important? RED Lanes may present opportunities to add bike lanes to a corridor and are compatible with complete streets design approaches, which cater to all travel modes. Moreover, effective transit service and walkable districts are mutually supportive, providing reliable non-auto travel options. The presence of non-motorized users does not necessarily elevate a corridor for RED Lanes consideration but may influence appropriate design choices for high-ranking corridors.

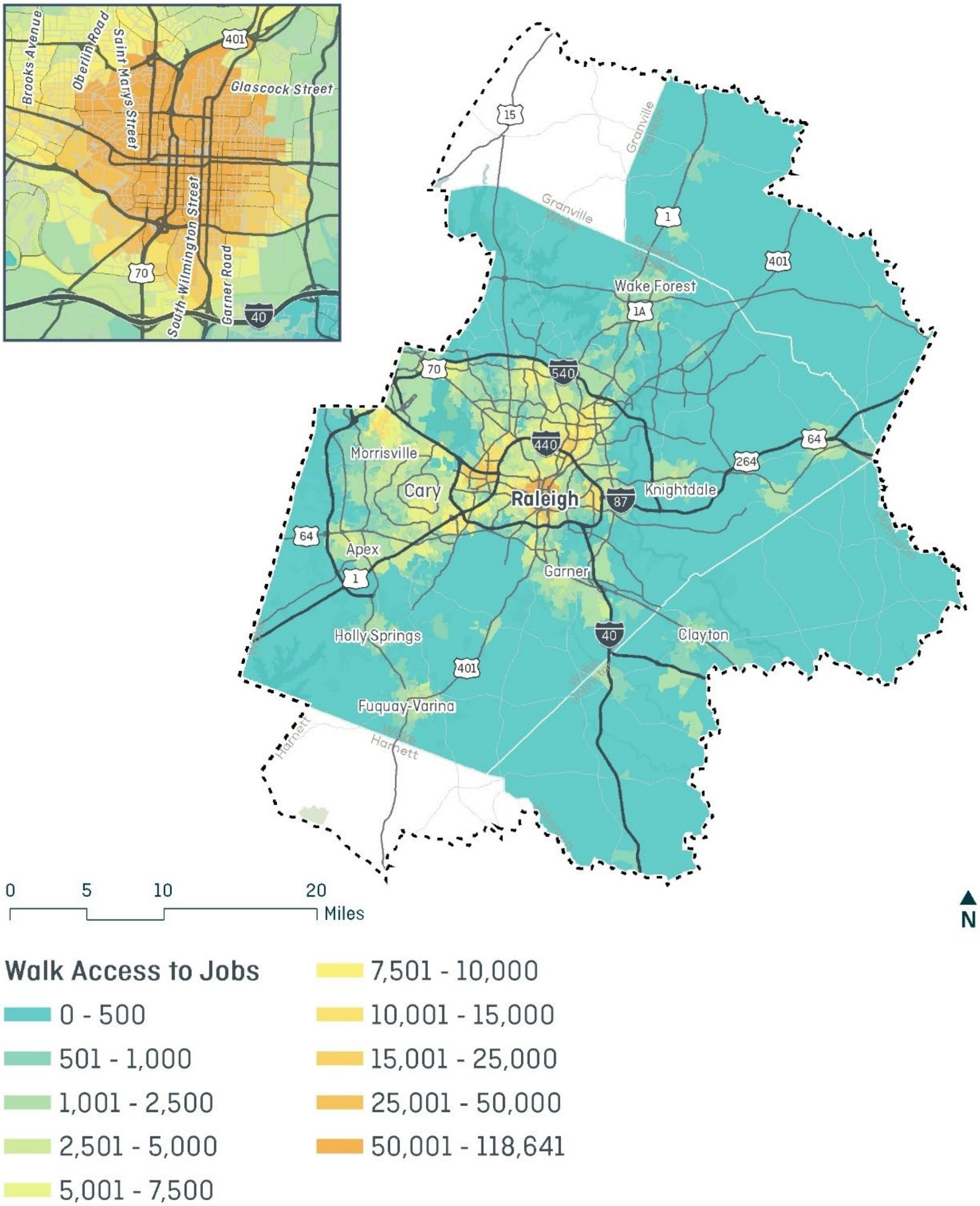
How is it measured? Ideal measures of non-motorized demand would mimic transit ridership and traffic volume measures, estimating the number of non-motorized users on a given segment or within a given corridor. However, comprehensive non-motorized trip data are difficult (and often costly) to obtain. For this reason, proxy measures reflecting factors related to non-motorized trip-making propensity are often utilized to better understand where demand for these trips is likely to be strongest. For this report, walk access to jobs is used to highlight areas with sufficient concentrations of and connectivity to trip attractors (jobs) to suggest a strong potential for non-motorized activity.

What data and tools are needed? Walk accessibility is best measured using fine-grained land use and travel network data. The Accessibility Observatory (AO) at the University of Minnesota[2] tracks accessibility trends over time at the census block level for the largest metropolitan areas in the country. The AO data are generated using LEHD[3] jobs data and OpenStreetMap[4] networks. Since the AO analysis focuses on metropolitan areas, portions of the CAMPO region outside the core metro area counties (Wake, Johnston, and Franklin) are missing walk access data. Since these data are expected to be used to help guide RED Lanes design decisions rather than for prioritization purposes, this gap is acceptable for the current report.

Findings: Non-motorized travel demand (walk accessibility) is highest in central Raleigh, including many in-town neighborhoods adjacent to Downtown Raleigh. Several prominent suburban centers are also visible, including the Blue Ridge Road from the Arena District to Crabtree Mall, northeast Raleigh from Triangle Town Center to I-440, and the WakeMed Hospital area along New Bern Avenue. Exurban town centers in Apex, Wake Forest, Fuquay-Varina, etc. are also notable on the map. In these areas (and in environs with similar walk access scores) RED Lanes implementation should include non-motorized facilities and/or amenities.

[2] http://ao.umn.edu/
[3] https://lehd.ces.census.gov/data/
[4] https://www.openstreetmap.org/

RED LANES | EXISTING CONDITIONS - WALK ACCESSIBILITY



Other notes: Walk accessibility has been shown to be a meaningful predictor of non-motorized demand.[5] Accessibility-based modeling could be used to estimate non-motorized demand and assign non-motorized trips to local networks. Future updates to the RED Lanes evaluation methodology could offer more robust non-motorized demand estimates at a segment level to better inform facility design decisions.

INDICATOR | PERSON THROUGHPUT

What is it? Person throughput describes the total number of people moving through a corridor, regardless of mode. For example, a carpool of three co-workers commuting to work would contribute three person trips to the person throughput value for the segments they traverse, while 25 people on a bus would contribute 25 person trips to the segments along the bus route between stops.

Why is important? Recognizing the tradeoffs associated with RED Lanes (see "Traffic Volume" above), RED lane efficiency can be measured by comparing expected person throughput on the RED lane (bus passengers plus other users including cyclists and turning vehicles as appropriate) to the person throughput on adjacent travel lanes. Person throughput can also be used in combination with segment delay metrics to identify per person delay metrics. Several studies cited in the literature review in the *RED Lanes Fundamentals* report utilized person throughput measures for evaluating transit priority lanes (TCRP 183, AASTHO, MDOT, e.g.).

How is it measured? Person throughput can be expressed as total person trips on a segment, collection of segments, or system in a given period of time. For RED Lanes analysis, segment level estimates are most appropriate. Person trips completed per interval of time can be used as a productivity measure but requires complete trip information.

What data and tools are needed? Person throughput analysis requires reliable segment-level data reflecting complete trips by all modes. The traffic volume estimates provided above would need to be embellished to account for vehicle occupancy; transit ridership would need to be disaggregated from route to segment level; and non-motorized trips would need to be estimated and assigned to travel networks. Thus, a person throughput measure requires substantial data development and analytical effort to reliably produce. The combination of more readily developed modal demand metrics (traffic volume, e.g.) provide ample insight into segment utilization to support the initial RED Lanes evaluation methodology. Person throughput analysis should be considered in potential future updates to the methodology as data resources and analytical approaches for multimodal travel evolve.

[5] http://www.trb.org/Main/Blurbs/171138.aspx

OPERATIONS

- Transit On-Time Performance
- Transit Service Frequency
- Transit Signal Priority
- Person/Vehicle Delay
- Average Travel Speed

TOPIC | OPERATIONS

RED Lanes are primarily focused on enhancing transit operations through the provision of transit priority lanes and supportive treatments, such as signal priority. Therefore, operational indicators are important considerations in identifying the suitability of RED lanes in a given corridor. Ideally, RED Lanes will be implemented in corridors where transit operations are critical for corridor mobility and/or where operations can be enhanced by the RED Lane. This section highlights existing and forecasted operational indicators, focusing on transit vehicle operations and service design, highlighting key findings to consider in developing the RED Lanes evaluation methodology.

INDICATOR | TRANSIT ON-TIME PERFORMANCE/TRAVEL TIME RELIABILITY

Core Technical Team input
Focus on targets, peak hour performance

Priority in evaluation methodology: High

What is it? Transit routes typically operate on a schedule, serving stops at predictable times and intervals. Deviations from the schedule – including early and late arrivals at stops – undermine reliability for transit passengers. On-time performance measures transit reliability and identifies locations that pose challenges to maintaining route schedules.

Why does it matter? RED Lanes are intended to confer travel time benefits to transit vehicles, reducing delays from congestion and enhancing travel time reliability along a route and potentially throughout the system. Measuring transit on-time performance helps to identify routes/segments where transit service is unreliable. These segments (and upstream segments as applicable) would likely see some of the greatest travel time reliability benefits from RED Lanes implementation as choke points are alleviated.

How is it measured? On-time performance is generally measured by recording the number of times a transit vehicle arrives early or late at a given stop or by looking at the number of on-time departures from the start of a route and/or arrivals at the end of a route. This value can then be compared to the total trips serving that stop or made by that route to calculate the on-time performance rate. Criteria must be devised to determine when a trip is early or late, such as no more than one minute ahead of schedule and no more than five minutes behind schedule. In this report, route-level on-time performance is presented. This reflects the proportion of trips for a given route that leave the route's start point and arrive at its end point on time during a one-month analysis period. While on-time performance is a useful indicator of transit reliability, it is worth noting that route (re)design and scheduling can help routes stay "on time," even as operational issues pose delays that undermine the competitiveness of the transit mode.

What data and tools are needed? On-time performance is best analyzed using automatic vehicle location (AVL) data. AVL records are often developed differently by/for different transit agencies and may not always be collected or maintained in the same manner even for agencies operating in the same geographic region.

Therefore, AVL metadata are important to support consistent application of the data across a region. Data cleaning and wrangling steps may be required to prepare all data for analysis, and this may be done using a variety of tools, such as R, Python, Excel, and/or GIS software. These tools are also suitable for analyzing on-time performance based on consolidated AVL records and generating findings. For this study, GoRaleigh and GoCary provided AVL-based on-time performance data at a route level. GoRaleigh data were provided for March 2019; GoCary data for September 2018. GoTriangle did not share on-time performance data for this study.

In the absence of robust AVL data, transit agency staff and vehicle operators can often provide meaningful insight into routes that struggle with on-time performance and specific locations that regularly contribute to delays. For this study, NCSU Wolfline staff identified three notable intersections and four segments that regularly affect on-time performance for Wolfline routes (see "Findings" section below for details).

Findings: Since the on-time performance data are provided at a route level, it is not possible to isolate specific segments as principal contributors to transit delays. However, it is apparent from the map that longer distance routes and those operating in suburban or exurban areas (especially as crosstown routes) are more prone to delays than shorter routes concentrated inside the I-440 beltline and focused on downtown Raleigh. In the RED Lanes evaluation methodology, route-level on-time performance information will likely need to be overlaid with segment-level traffic and delay information (discussed elsewhere in this report) to identify segments where RED Lanes can be expected to improve on-time performance. The routes with on-time performance rates of 85% or below are shown in Table 3 below. Table 4 lists the key intersections and segments that regularly introduce delays for the NCSU Wolfline services.

Table 3 Routes with On-Time Performance Rates of 85% or Lower

Route	On-Time Performance Rate
GoCary – 5X Kildaire Farm Express	59%[6]
GoRaleigh – 18S Poole Rd	63%
GoRaleigh – FRX Fuquay-Varina Express	65%
GoRaleigh – 26 Edwards Mill	68%
GoRaleigh – Wake Forest Loop	69%
GoRaleigh – 27 Blue Ridge	70%
GoRaleigh – 63X (KDX) Knightdale Express	70%
GoRaleigh – 40X Wake Tech	70%
GoRaleigh – 70X Brier Creek Express	71%
GoRaleigh – ZWX Zebulon/Wendell Express	72%
GoRaleigh – 102 Garner	72%
GoRaleigh – 18 Poole-Barwell	73%
GoRaleigh – 23L Millbrook Crosstown	74%
GoCary - Route 5 - Kildaire Farm Road	75%
GoRaleigh - 5 BILTMORE HILLS	76%
GoCary - Route 4 - High House Road	76%

[6] On time performance rate for August, 2019. September data showed an unexpectedly low on-time performance rate of 17%.

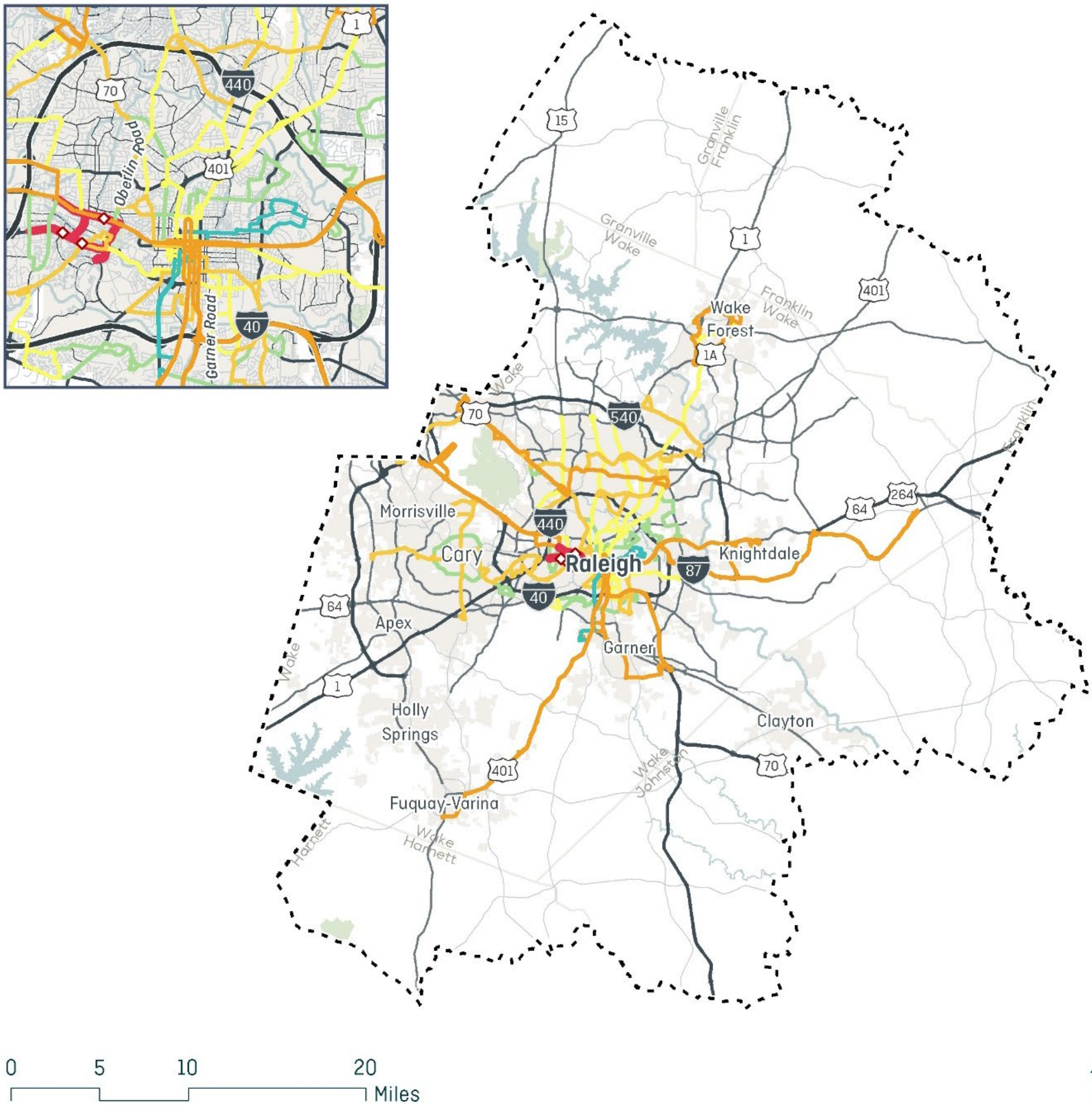
Route	On-Time Performance Rate
GoCary - Route 3 - Harrison Ave	77%
GoRaleigh - 11l Buck Jones	77%
GoRaleigh - 24l North Crosstown	78%
GoRaleigh - 21 Caraleigh	78%
GoCary - Route 6 - Buck Jones Road	78%
GoRaleigh - 25l Triangle Town Center	79%
GoRaleigh - 36 Creedmoor	80%
GoRaleigh - 22 State Street	80%
GoRaleigh - 16 Oberlin Road	80%
GoRaleigh - 8 Six Forks	81%
GoRaleigh - 11 Avent Ferry	81%
GoRaleigh - 13 Chavis Heights	81%
GoRaleigh - Wake Forest Express (WFX)	81%
GoRaleigh - 55x Poole Road Express	82%
GoRaleigh - 4 Rex Hospital	83%
GoRaleigh - 2 Falls Of Neuse	83%
GoRaleigh - 17 Rock Quarry	84%

Table 4 NCSU Wolfline Locations that Impact On-Time Performance

Intersections	Segments
• Avent Ferry Rd./Morrill Dr./Western Blvd. • Hillsborough St./Horne St./Lampe Dr. • Western Blvd./Varsity Dr	• Western Blvd. - Method Rd./Kent Rd. to Pullen Rd. • Hillsborough St. - Faircloth Rd./Gorman St. to Pullen Rd. • Dan Allen Dr. - Western Blvd. to Hillsborough St. (4:00 pm-6:00 pm) • Pullen Rd. - Bilyeu St. to Stinson Dr.

Other notes: Challenges related to assessing or forecasting transit on-time performance include dependence on detailed travel modeling procedures; imprecise apportionment of observed delays along a route, complicating clear articulation of appropriate RED Lane implementation limits; and inconsistencies in detailed vehicle location data requiring substantial pre-processing, such as reported dates, organization of information, or metrics generated across all transit agencies. Developing uniformity in AVL datasets across all transit providers in the region could simplify the process of developing more detailed on-time performance metrics. Recommendations for developing such consistency is beyond the scope of this report. Forecasting on-time performance is difficult on a regionwide basis as schedule adherence issues often arise from fine-grained factors that are too minute to account for in regional forecasting models. Additionally, for routes that offer frequent service, headway adherence is often preferred over on-time performance for travel time reliability metrics. Headway adherence data were not made available from the region's transit providers for this study. Future enhancements to the RED Lanes evaluation methodology could include the use of stop-level on-time performance metrics to precisely locate the primary segments that cause certain routes to deviate from their schedules. This would create a more focused metric for RED Lane analysis.

RED LANES | EXISTING CONDITIONS - ON TIME PERFORMANCE



Share of route trips departing and arriving on-time (2018/19)

- 75% or less
- 75.1% - 80%
- 80.1% - 85%
- 85.1% - 90%
- Over 90%

Intersections affecting NCSU Wolfline Routes

Segments affecting NCSU Wolfline Routes

On-time performance for GoRaleigh (March 2019) and GoCary (September 2018).

NCSU Wolfline staff highlighted key delay point in the NCSU campus area.

INDICATOR | TRANSIT SERVICE FREQUENCY

Core Technical Team input
Focus on planned frequency

Priority in evaluation methodology: Low

What is it? Transit service frequency describes the regularity and intervals at which a transit vehicle serves a stop location of traverses a street segment. Transit routes often operate at regular intervals (headways), such as “every 30 minutes” or “every 15 minutes.” When multiple routes serve a given corridor, connectivity between common stops will be more frequent than the route headways.

Why does it matter? There is a strong consensus in the literature that RED Lanes are most appropriate in corridors and segments with transit service operating at high frequencies. The maximum recommended headway for RED lane applications is 15 minutes, but transit lanes are generally considered to be most effective at higher frequencies, when transit utilization of a lane becomes “self-enforcing” due to the high frequency of service. Further, more frequent transit service is associated with higher transit ridership. Therefore, identifying existing and planned high-frequency corridors is essential to understanding where RED Lane implementation is most appropriate.

How is it measured? Transit service frequency is most commonly measured as the number of buses per hour along a route or along a segment. Since RED Lanes are expected to serve multiple routes in many cases, this report focuses on segment-level frequency. Existing segment-level frequency is presented for current transit service during the PM peak travel period on a typical weekday. Service frequencies reflect bi-directional buses per hour, since RED Lanes will typically be implemented symmetrically. Rates above 8 buses per hour approximate the minimum suitable for RED Lanes.

For planned transit service, future high frequency services from the Wake Bus Plan (WBP) and Metropolitan Transportation Plan (MTP) have been mapped. Segments with planned headways of 15 minutes or less are highlighted based on the year in which the high-frequency service is planned to be implemented.

What data and tools are needed? Transit service frequency by route and time period can be readily calculated using GTFS transit data. GTFS feed nuances can present challenges, such as combining separate GTFS feeds and identifying overlapping routes and stops. For example, multiple bus routes from multiple transit agencies can traverse the same roadway segment. Therefore, in order to calculate a frequency analysis that incorporates more than one route, it is necessary to align all routes onto a common street network. Thus, a substantial portion of the analysis involves assigning trips represented in the GTFS feeds to a consistent array of roadway segments. This portion of the analysis was conducted by utilizing spatial scripts provided as part of an open source tool developed and published by U.S. Department of Transportation (USDOT). [7] This tool contains spatial scripts that are designed to align GTFS networks, obtained from respective transit agencies and merged into a single SQLite database, with FHWA’s All Road Network of Linear Referenced Data (ARNOLD), a nationwide road network dataset that was obtained from USDOT staff. Although not completely comprehensive, the ARNOLD network represents most roadway segments in the CAMPO region suitable for RED Lanes analysis (features omitted from ARNOLD are generally

[7] https://github.com/VolpeUSDOT/gtfs-measures/blob/master/docs/GTFS_Script_Documentation.md

local residential streets). After manually cleaning GTFS feeds and interpolating blank stop times, the USDOT scripts were utilized to ingest the various GTFS feeds reflecting all services in the CAMPO region and assign the routes to the ARNOLD network. The tool, which requires ArcGIS's Network Analyst extension and Python scripting knowledge to run, uses network routing algorithms to identify which ARNOLD segments the GTFS shapes and stops should be placed on. Finally, to calculate the frequency metric, trips per route shape were queried from the SQLite dataset of combined GTFS feeds created by the USDOT tool. These records were then able to be related to the number of trips scheduled on each ARNOLD segment during the peak period of 4:30 p.m. to 7 p.m. on a typical Wednesday. The resulting frequency estimates were joined to the ARNOLD road network and the results were mapped.

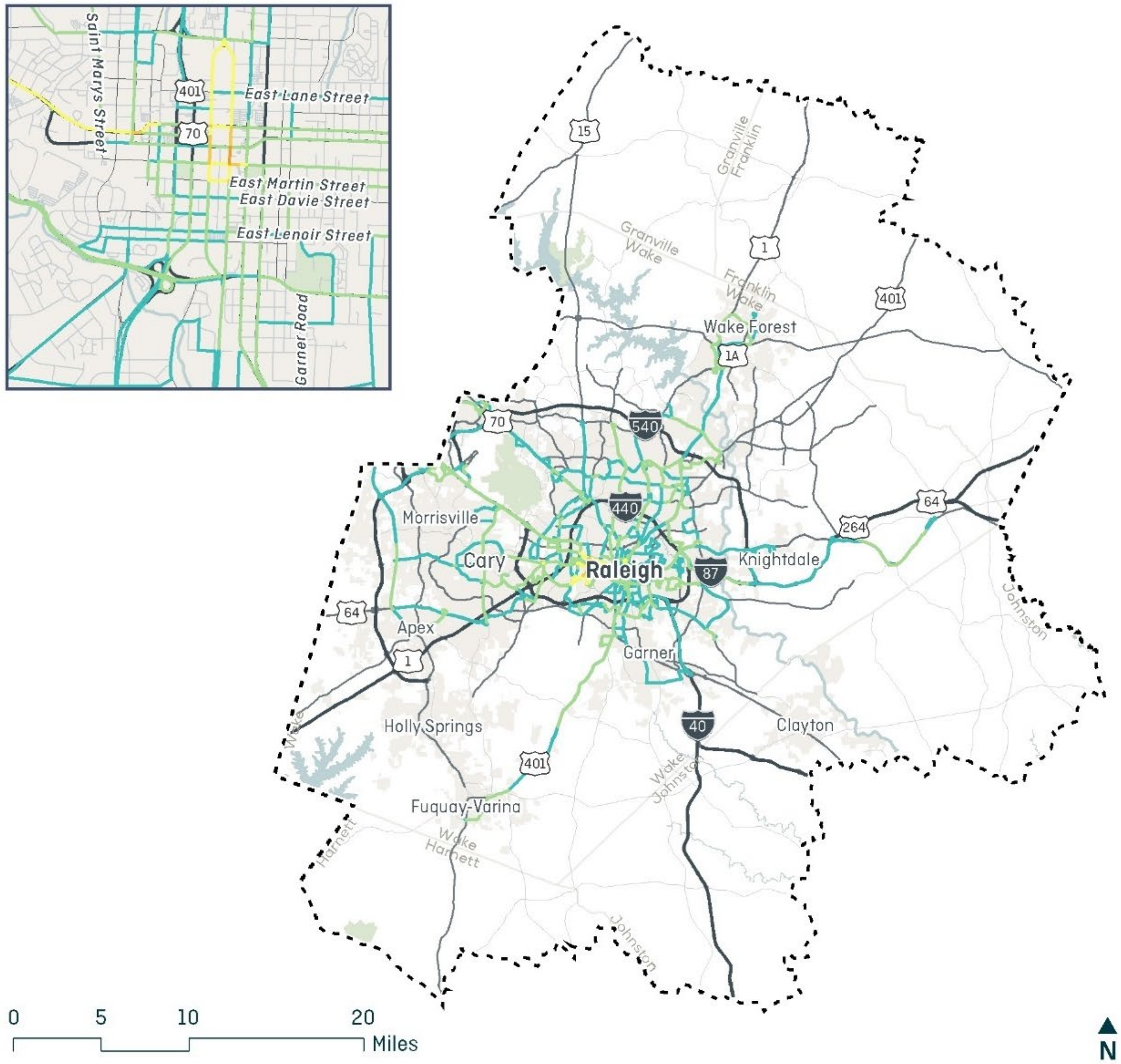
For planned service frequency, high frequency routes were selected from line features reflecting the WBP and MTP planned transit alignments.

Findings: During peak hours, a large portion of the network in the study area operates at rates of 1-4 buses per hour, or with one bus or fewer every 15 minutes on a bi-directional basis (i.e., one-bus per 30 minutes in each direction). As routes converge, particularly in Raleigh, cumulative frequencies begin to rise. In certain areas, the analyses show that isolated segments can see frequencies up to 22 buses per hour, or approximately one every 3 minutes on a bi-directional basis. While there is not a uniform threshold that is supportive of RED Lanes, it is generally recognized that transit lanes are most effective in areas where transit service is frequent enough to be self-reinforcing.

Planned high frequency service is concentrated in the urban heart of the CAMPO region, mostly within the I-440 beltline. The near-term frequent service priorities are on north-south and east-west urban axes through downtown Raleigh.

Other notes: The map of planned service frequency assumes bi-directional service on all segments overlaid on a future transit route alignment. In some cases, route alignments use loops or lariats that will only travel in a single direction. Accounting for these route components requires fracturing the original planned transit routes linework and denoting which line segments are bi-directional versus a single direction of travel. In light of the diverse indicators and data preparation needs for this report, this embellishment was not undertaken for the current analysis. Since most planned routes are predominantly comprised of bi-directional segments, there is minimal risk of the bi-directional assumption giving undue priority to a uni-directional segment in the RED Lanes evaluation methodology. However, future enhancements to the methodology may consider refining the future bus alignment data to differentiate bi-directional and uni-directional segments.

RED LANES | EXISTING CONDITIONS - TRANSIT SERVICE FREQUENCY



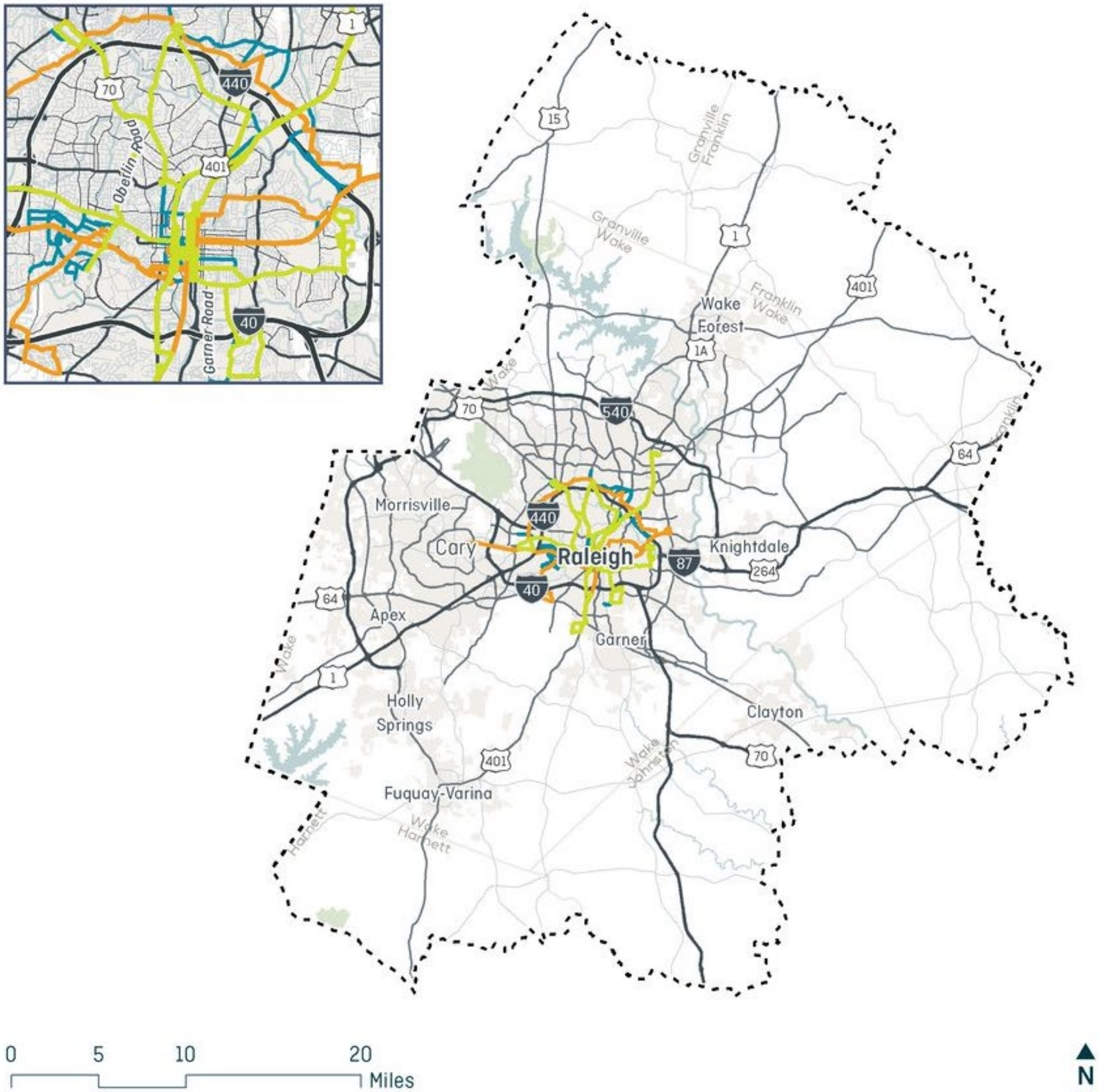
Peak Hour Service - Trips Per Hour

- 1
- 2 - 4
- 5 - 8
- 9 - 12
- 13 - 22

Transit Service Frequency

DEMAND | OPERATIONS | CONTEXTS | DESIGN

RED LANES | EXISTING CONDITIONS - PLANNED SERVICE FREQUENCY



Planned High Frequency Service by Implementation Horizon

- by 2024
- by 2027
- by 2045

High frequency service is defined as a route headway of 15 minutes or shorter in the peak period.

INDICATOR | TRANSIT SIGNAL PRIORITY

Core Technical Team input

Priority in evaluation methodology: Medium

What is it? Transit Signal Prioritization (TSP) is a method for increasing transit vehicle speed and improving reliability through the adjustment of signal timing at intersections. TSP typically extends a green phase or truncates a red phase if a transit vehicle is attempting to enter an intersection, thereby decreasing the delay likely to be experienced at a signalized intersection.

Why is it important? Transit signal priority (TSP) can be an effective supporting component alongside the implementation of a RED Lanes project. As a companion strategy to a transit priority lane, TSP can alleviate delays at intersections and improve travel time reliability. TSP is most effective along corridors with v/c ratios between 0.8 – 1.0 (see "Traffic Volume" above for more information).

How is it measured? Since TSP is primarily an operational improvement strategy rather than a factor determining RED Lane suitability, there is no typical metric quantifying TSP. The presence of TSP, and - more broadly - Intelligent Transportation Systems (ITS) signaling infrastructure could potentially inform the prioritization of candidate corridors for RED Lanes, as it indicates a planned or existing presence of supportive technology. However, data indicating where TSP or supporting ITS infrastructure are in-place or planned were unavailable for this report.

It may be possible to utilize other metrics generated for this report – transit on-time performance and traffic volume v/c ratios, specifically – to develop a coarse TSP suitability score for candidate corridors. This could help guide RED Lane design and implementation to consider TSP in appropriate contexts. The suitability score would highlight segments or intersections traversed by bus routes with observed downstream on-time performance issues and TSP-supportive v/c ratios. However, because this study is focused on RED Lanes and not TSP as a stand-alone improvement, developing a TSP suitability score is a low priority.

What data and tools are needed? Data identifying where TSP or TSP-supportive technologies are currently installed or planned within the region would ideally be available to inform the RED Lanes evaluation methodology. GIS software would be used to relate existing or planned ITS or TSP to study segments.

Challenges exist in developing an appropriate formulation of a TSP suitability score, as there is not a definitive best practice methodology prescribing how to combine diverse measures for this application. Data needs for a simplistic approach could include intersection LOS; segment v/c ratios; on-time performance rates; and a signals location dataset.

Findings: Several corridors are currently being studied for operational and transit-supportive strategies, including TSP. These include NC 54 from downtown Cary to Morrisville or an alternative route using McCrimmon Parkway; US 70 from Garner Station to Clayton; Western Boulevard in portions being studied for BRT; Wilmington Street in portions being studied for BRT; and along sections of Capital Boulevard.

Other notes: (None)

INDICATOR | PERSON/VEHICLE DELAY

Core Technical Team input

Priority in evaluation methodology: Low

What is it? Delays in transportation are disruptions of travel time expectations, often arising from degradations in travel conditions. For example, delays are created when highways become congested and operate at speeds significantly lower than their typical operating speeds or when a connection between two places is severed by construction activity or a train crossing. Delays usually impact all vehicles utilizing an effected corridor or segment, including buses. While some instances of delay arise from unusual events or circumstances, many are systematic and recurrent in nature – such as congestion-related delays during peak travel periods.

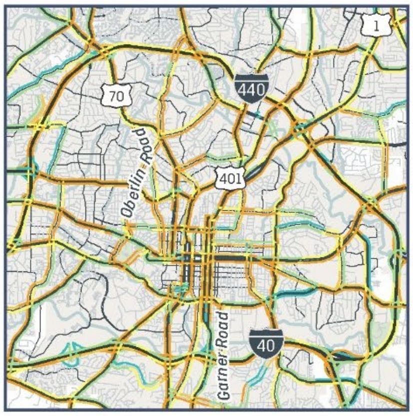
Why is it important? Recurrent delay affects the efficiency and reliability of transit services. RED Lanes and related transit priority treatments are intended to improve the reliability and speed of transit services, and in many cases, they have been implemented specifically to address issues arising from systemic delays. According to the literature reviewed for the *RED Lane Fundamentals* report, RED Lanes are most effective when implemented in corridors with moderate-to-heavy congestion-related delay. In corridors with minimal delay, RED Lanes are unlikely to confer significant travel time savings.

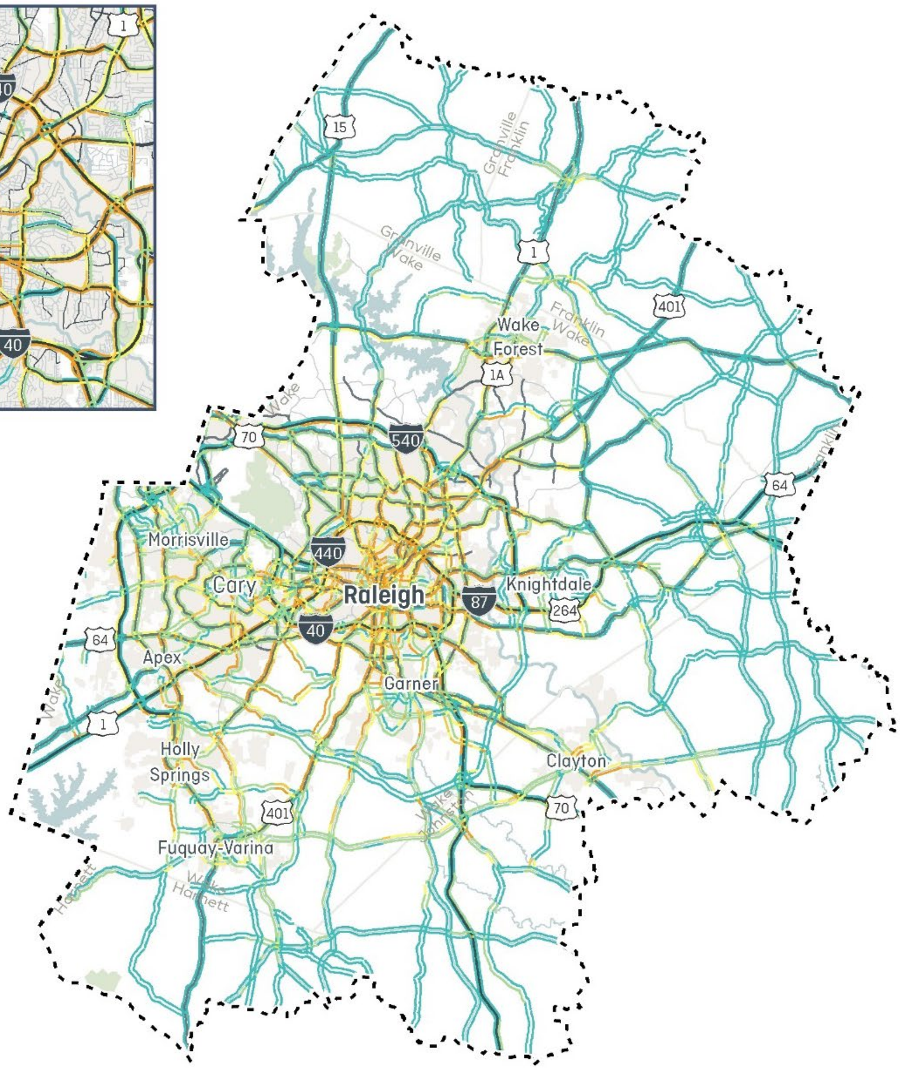
How is it measured? A simple formulation of delay is the ratio of congested speed to free flow speed on the highway network for 2045. This reflects anticipated systematic, recurrent delays consistently on a regionwide basis using readily available datasets and tools.

What data and tools are needed? Estimated congested and free flow highway speeds are generated by the Triangle Regional Model (TRM) and reported at a segment level on the loaded highway network.

Findings: The degree to which congestion degrades travel speeds relative to free-flow conditions can be expressed using a congested-to-free-flow (C:FF) speed ratio. The C:FF ratio for the CAMPO region in the AM peak period is shown in the map below, based on the TRM's 2045 loaded highway network. Arterial delays are most common in the heart of the region, focused on Raleigh and Cary. The area inside the beltline is most effected by congestion with many links operating at 75% of free flow speeds or slower. In many cases, the delays are expected in both travel directions. Other concentrations of delay can be seen in Northeast Raleigh, South Raleigh-Garner, and (to a lesser degree) southwestern Wake County. Select segments exhibit congestion-related delays throughout other part of the region. In most cases, delay is experienced in the peak commuting direction on facilities outside the beltline. In corridors with heavy peak directional flow, part time RED Lanes may be warranted.

RED LANES | EXISTING CONDITIONS - VEHICLE DELAY





0 5 10 20 Miles

N

2045 Congested-to-free-flow-speed ratio by direction (PM Peak Period)

- 65% or less
- 65.1% - 75%
- 75.1% - 85%
- 85.1% - 95%
- 95.1% - 100%

Other notes: There are many approaches to measuring delay metrics. Detailed approaches often require developing multiple underlying metrics for diverse modes, resulting in complex analyses and data coordination needs. Person delay is recommended for transit-oriented analyses by the American Association of State Highway and Transportation Officials (AASHTO) Transit Design Guide[8] because it accounts for all passengers/travelers instead of focusing on vehicles only. Meanwhile, transit vehicle dwell time is delay metric that can provide insight into intersections causing significant delays, which can then be targeted for companion spot improvements such as TSP or queue bypasses.

In all cases, detailed delay metrics pose time and cost challenges related to the complexity of integrating multiple datasets, purchasing proprietary data sets, and accounting for variance between observed conditions and modeled data at specific locations. Some commonly used delay metrics include delay rate;[9] relative delay rate;[10] delay ratio;[11]; total delay (measured in vehicle-minutes);[12] and transit vehicle dwell time at intersection (derived from AVL data). Supporting data sets could include TRM loaded networks; HERE Traffic Analytics (average historical speed); GTFS schedule (transit vehicle speed); NCDOT Traffic Segments (posted speed limit); and transit agency AVL data.

[8] See *TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies*, 2016. https://www.nap.edu/download/21929 (section 4.2)

[9] Actual travel rate (mins/mi) – acceptable travel rate (mins/mi)

[10] Delay rate / acceptable travel time

[11] Delay rate / actual travel time

[12] Actual travel time (mins) - acceptable travel time (mins) x volume

INDICATOR | AVERAGE TRAVEL SPEED

Core Technical Team input

Priority in evaluation methodology: Low

What is it? Transit travel time is directly related to the typical speed maintained by transit vehicles. Transit travel speeds tend to be lower than those for adjacent cars as buses make stops to allow passengers to board and alight the vehicle. In some cases, agencies or regions adopt transit travel speed service standards to evaluate route performance. The standards and monitoring of travel speed can help support route planning and stop-placement decisions with a focus on maintaining competitive travel speeds.

Why is it important? RED Lanes are intended to enhance travel speed for transit vehicles without unduly impacting travel conditions for motorists. An average travel speed analysis is useful to identify corridors where transit vehicle speeds are expected to be slow and/or drop below service standard targets.

How is it measured? Travel speed service standards are typically applied at the route level, but segment-level analysis helps identify specific locations where speeds are reduced. In this report, peak-hour segment-level estimated transit speeds for 2045 are presented. Speed estimates are expressed in miles per hour.

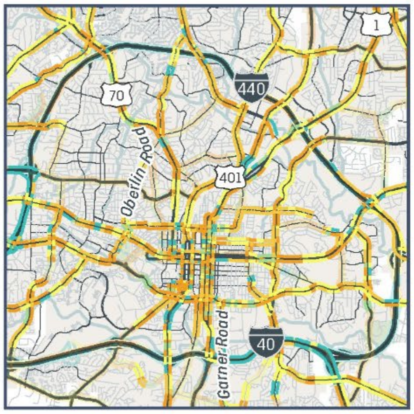
What data and tools are needed? Estimated peak-hour transit speeds are available from the Triangle Regional Model (TRM). Bus speeds are estimated based on TRM loaded highway network attributes, segment facility type, and speed curves used in the TRM. Bus speed estimates can be calculated for all segments in the TRM highway network but are most meaningful for segments utilized by transit vehicles. Results for all segments are presented here, but segments with no planned transit service in 2045 are muted in the map through opacity reductions. In this way, bus speeds can be seen for all roads that could potentially have transit operations, but the focus remains on roads that have existing or planned service.

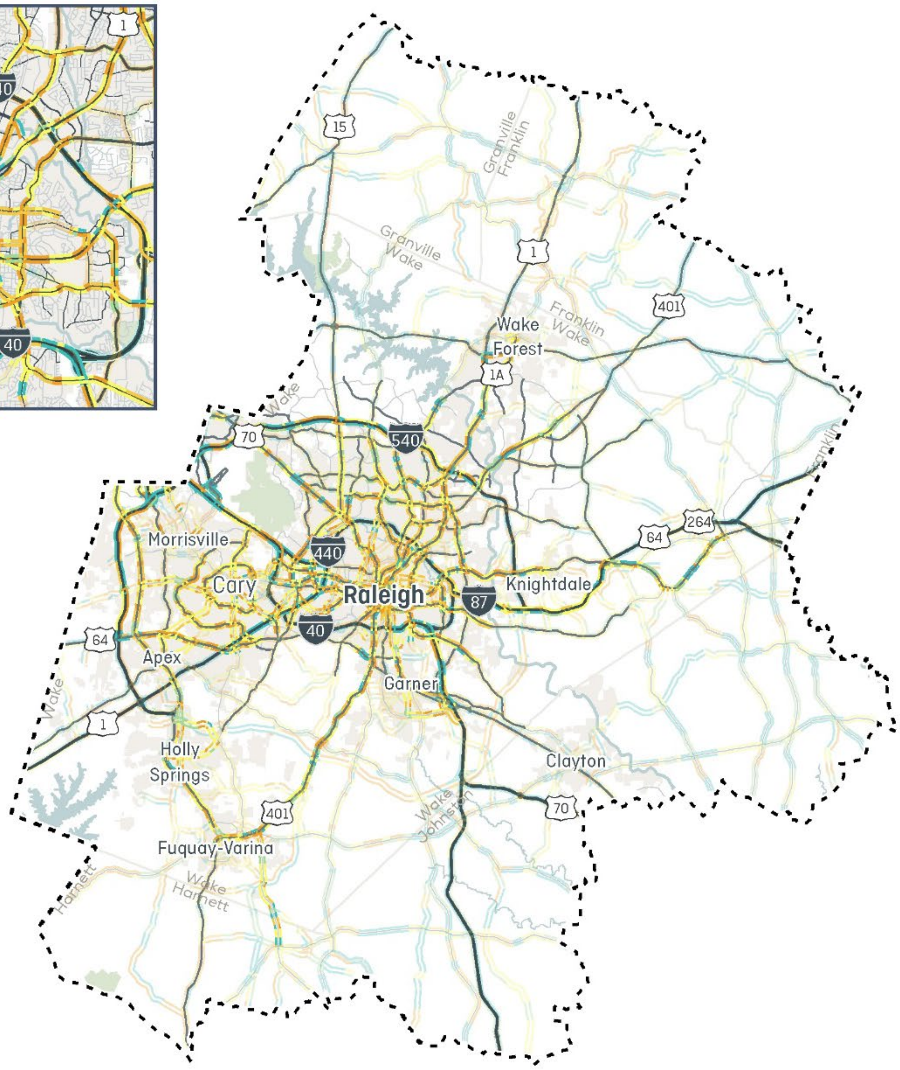
Findings: Based on the TRM estimates, bus speeds are generally slow throughout the CAMPO region except on rural routes (most of which have no planned transit service) or on expressway segments. The Wake County Transit Plan's BRT Design Standards[13] use a 16 mph standard for BRT projects, and most segments with planned transit in 2045 fall below that threshold. No specific RED Lanes service standard for travel speeds is envisioned, but average speeds between 12 and 16 mph are probably appropriate as loose targets. Segments estimated to operate below 12 mph may be most suitable for RED Lanes improvements to boost travel speeds, all else being equal. Most of these segments are found within the I-540/NC-540 loop.

Other notes: Other approaches to analyzing transit travel speeds are conceivable, though they typically require greater data and computational resources than the TRM-based estimates presented here. Existing speeds can be estimated based on schedule data from GTFS feeds or from observed trends using AVL and/or vehicle probe data sources. Microsimulation approaches could provide detailed insight into transit operating speeds within a corridor and the impacts of RED Lanes on operating speeds. However, these approaches are not suitable for a regionwide analysis like the evaluation methodology envisioned in this study.

[13] http://goforwardnc.org/wp-content/uploads/2018/11/Wake-MIS-BRT-Design-Standards-Performance-Measures-FINAL.pdf

RED LANES | EXISTING CONDITIONS - TRANSIT TRAVEL SPEED





0 5 10 20 Miles

N

2045 Estimated bus travel speed by segment

- 0 - 8
- 9 - 12
- 13 - 16
- 17 - 20
- 21 - 70

Bus speed estimated for all segments in TRM 2045 highway network.

Segments without planned transit service by 2045 are muted.

CONTEXTS

- Adjacent Land Uses
- Context Classification/ Complete Streets
- Accessibility
- Facility Functional/Access Class

TOPIC | CONTEXTS

Indicators in the Contexts topic area focus on land uses and activity within or adjacent to a corridor, The corridor's role in the regional transportation system, and the relevant policies impacting general corridor improvement strategies and design approaches. In some cases, context considerations are applicable for prioritizing candidate corridors for RED Lanes suitability. For example, RED Lanes are most appropriate in areas with transit supportive land use characteristics, such as high density and diverse building types. In other cases, context considerations inform the appropriate implementation approaches for RED Lanes in a given priority corridor. Contextual information should generally account for local plans and growth strategies in addition to current conditions to the extent feasible.

INDICATOR | ADJACENT LAND USES

Core Technical Team input
Focus on disadvantaged populations

Priority in evaluation methodology: Medium

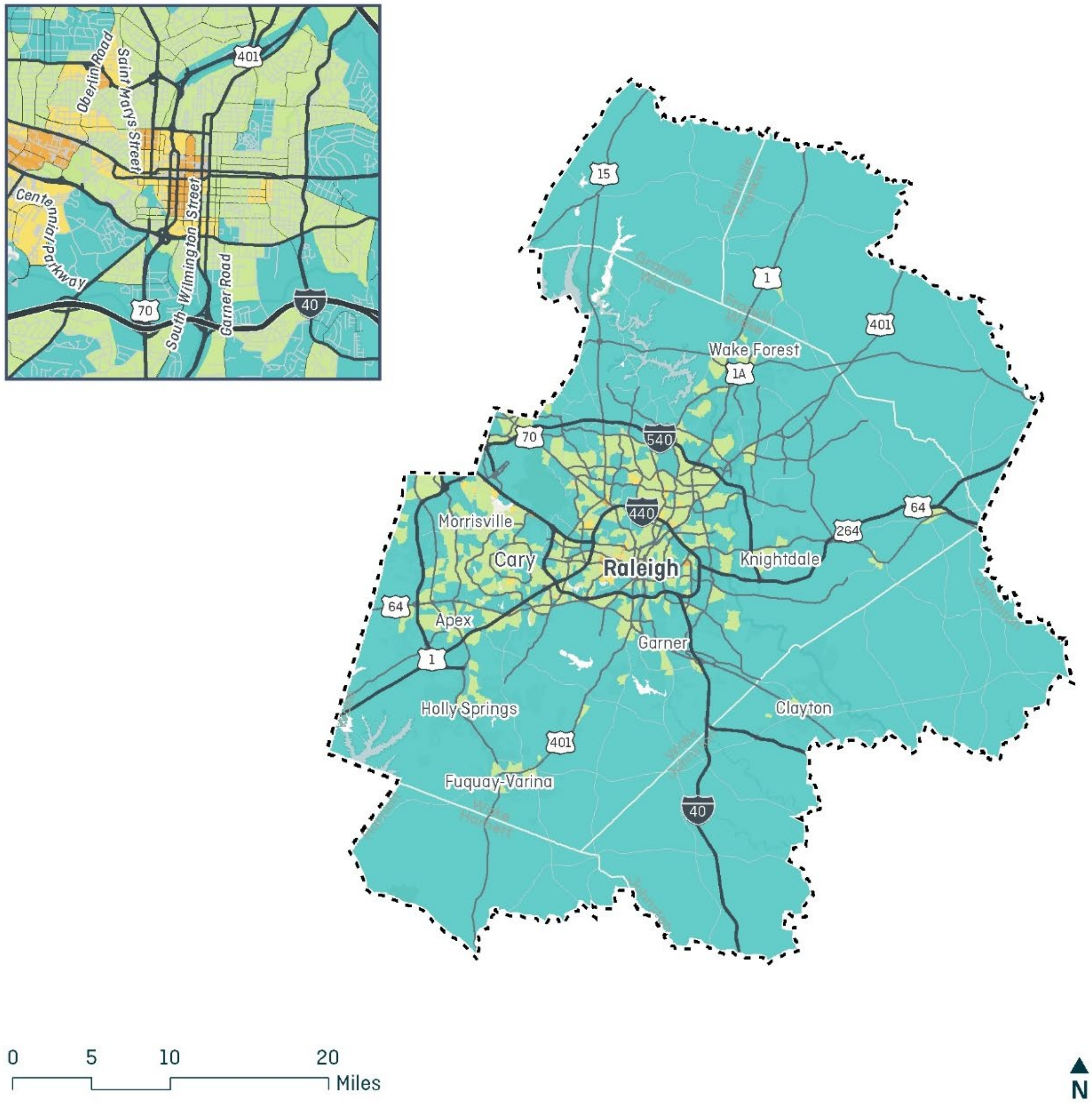
What is it? Adjacent land use considerations describe how the area surrounding a corridor is developed, including the number and diversity of activities present. Areawide design considerations describe how these activities are organized and connected to each other.

Why does it matter? Adjacent land use analyses provide information that can inform which corridors traverse transit-supportive districts, which corridors are likely to offer the greatest benefits to the most users from transit-priority enhancements, and which corridors are in areas with RED Lanes supportive policy areas.

How is it measured? A variety of metrics can be used to measure adjacent land uses. For this report, activity unit density, or the number of jobs and people per acre, was selected as a simple metric that provides insight into the density of land uses along a corridor. Activity unit density is an indicator of a transit-supportive context. Intersection destiny is commonly used to describe neighborhood design and understand connectivity for pedestrians. Areas with higher intersection densities are generally more walkable, and more supportive of multimodal travel. For this report, thresholds for activity unit and intersection densities were derived from *TCRP Research Report 187: Livable Transit Corridors: Methods, Metrics, and Strategies*. This report identifies corridor typologies for "emerging," "transitioning," and "integrated" and provides guidelines which were used to identify the thresholds used in this report. [14]

[14] National Academies of Sciences, Engineering, and Medicine. 2016. Livable Transit Corridors: Methods, Metrics, and Strategies. Washington, DC: The National Academies Press. https://doi.org/10.17226/23630.

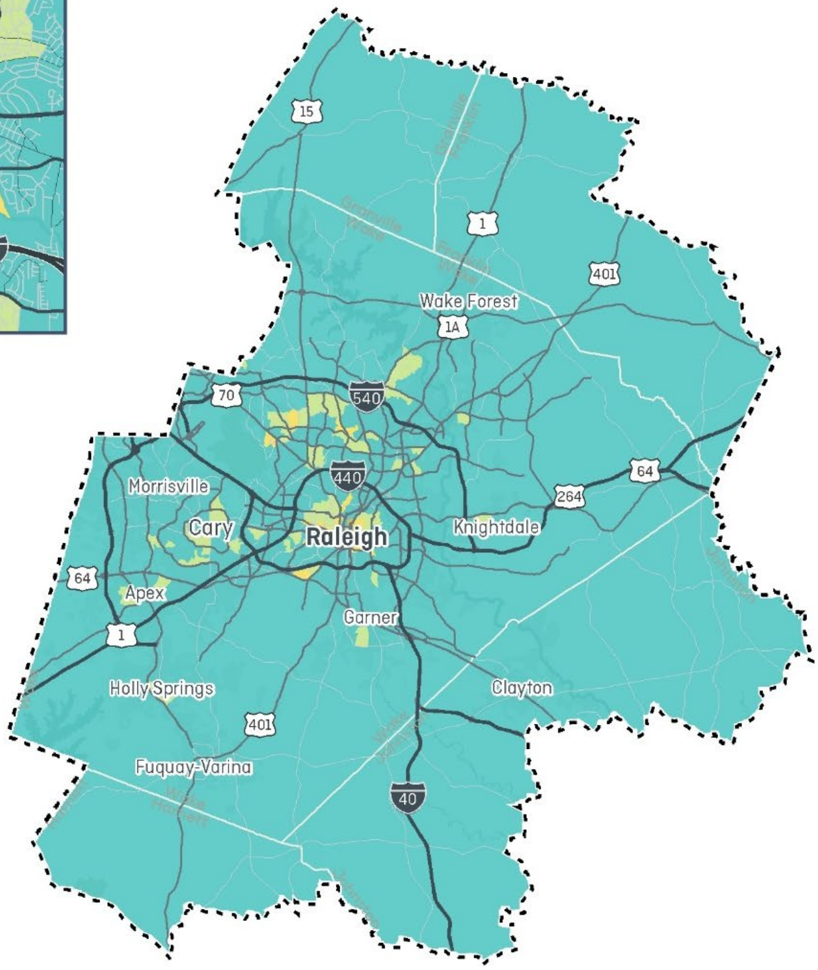
RED LANES | EXISTING CONDITIONS - ACTIVITY UNIT DENSITY



Transit Supportive Activity Unit Densities (Jobs+Pop Per Acre)

- Below Emerging (0-5)
- Emerging (6-21)
- Transitioning (22-49)
- Integrated (50-780)

RED LANES | EXISTING CONDITIONS - INTERSECTION DENSITY



0 5 10 20 Miles

N

Intersection Density Per Mile

- Below Emerging (0 - 70)
- Emerging (71 - 100)
- Transitioning (101 - 226)
- Integrated (227+)

Adjacent land uses

DEMAND | OPERATIONS | **CONTEXTS** | DESIGN

What data and tools are needed? For activity unit density, the Triangle Regional Model (TRM) zonal data provides the number of jobs and population in each zone. The base 2013 land zonal data was utilized to calculate the number of activity units per acre. The EPA Smart Location Database[15] contains intersection densities, with coverage of the full study area at a block group resolution. Thresholds derived from TCRP Research Report 187, a guidebook intended to support planning for livable transit corridors, are useful for plotting activity unit and intersection densities.

Findings: Activity unit densities reach the "emerging" and higher categories in several areas within the study area. The most prominent area is downtown Raleigh, which contains "Emerging," "Transitioning," and "Integrated" areas. Additionally, the area stretching north from Raleigh towards Wake Forest is notable. In addition, the centers of Cary, Morrisville, Apex, Holly Springs, Fuquay-Varina, Clayton, Knightdale, and Wake Forest also contain "Emerging" threholds that are clearly visible on the map. The intersection density analysis reveals a similar pattern as activity unit density, with notabely fewer areas reaching the "Emerging" and above thresholds. Outside of Raleigh, notable areas that reach "Emerging" and above intersection densities are Apex, Carey, Knightdale, Garner, and areas northeast Raleigh stretching toward Wake Forest. These maps provide a simple but effective basis for identifying the areas in the CAMPO regiona that are the most transit-supporitve based on existing adjacent land use factors.

Other notes: Activity unit (jobs + people) and intersection density are simple and powerful indicators for measuring the density and design along a corridor, thereby indicating how transit-supportive the built environment may be. Additional metrics can provide a deeper level of insight and can supplement the basic density indicators included in this report. TCRP Research Report 187 outlines a variety of more specific metrics, many of which can be derived from the same data sources outlined in this report.

15 https://www.epa.gov/smartgrowth/smart-location-mapping

INDICATOR | CONTEXT CLASSIFICATION/COMPLETE STREETS

Core Technical Team input
Priority in evaluation methodology: Medium

What is it? Context Classification and Complete Streets are mutually supportive policy approaches that base roadway design decisions on contextual features, such as built environment characteristics adjacent to the roadway, and on the people that use a facility to safely and comfortably accommodate all users across modes.

Why is it important? By establishing transit priority lanes and allowing shared users as appropriate, RED Lanes are compatible with complete streets design principles. In appropriate contexts, RED Lane project design should incorporate facilities and/or amenities that enhance the travel experience for pedestrians and bicyclists in addition to transit riders.

How is it measured? Complete Streets design approaches are emerging as a new standard for roadway design. In years past, identifying corridors where Complete Streets policies were in-place would have been a useful metric contributing to the RED Lanes evaluation methodology. Given the broad adoption of Complete Streets approaches, this is no longer a meaningful differentiator among segments. Rather, Complete Streets help define how a RED Lane project should be designed and implemented in differing contexts.

Context classification is a separate analytical process that helps define the specific contexts in which a roadway is situated. Context classification often uses a "transect" scale to rank contexts on a rural-to-urban continuum and convey appropriate design strategies based on the local setting and facility characteristics, such as functional class. Context classification analyses typically rely on an array of diverse datasets and require substantial methodological development for local/regional application. As such, context classification measures are beyond the scope of this report.

What data and tools are needed? NCDOT adopted a "Complete Streets" policy in 2009 (described below). Since the policy impacts design approaches across the state, no additional data or tools are needed for the current report. Complete Streets principals are discussed briefly below and should be applied in RED Lane project designs.

Findings: According NCDOT's Complete Streets policy, design engineers must consider and/or incorporate more than one mode of transportation for new projects or when making transportation improvements. The benefits of Complete Streets, identified by NCDOT include:

- making it easier for travelers to get where they need to go;
- encouraging the use of alternative forms of transportation;
- building more sustainable communities;
- increasing connectivity between neighborhoods, streets, and transit systems; and
- improving safety for pedestrians, cyclists, and motorists.[16]

[16] https://www.completestreetsnc.org/

NCDOT issued "Complete Streets Planning and Design Guidelines[17]" in 2012 and in 2018 undertook a comprehensive evaluation of the State's approach to Complete Streets at the direction of Transportation Secretary James H. Trogdon.[18] A group of stakeholders representing communities across the state provided feedback on strengths, weaknesses, and opportunities to inform potential improvements to the State's Complete Streets program. A series of statewide workshops are ongoing through 2019, supporting implementation of complete streets in North Carolina communities. Transit priority strategies like RED Lanes support the implementation of complete streets in the CAMPO region and set a precedent for other communities across North Carolina. Additionally, RED Lanes present a potentially cost-effective solution for improving transit operations and service reliability that can help meet growing transportation demand, improve transit operations, and diversify modal options for local and regional travel.

Other notes: As Complete Streets policies and practices mature, having a consistent and robust systemwide definition of context classifications can clarify and simplify the selection of appropriate improvement strategies and design options for various corridors. While developing such a context classification methodology is outside the scope of the RED Lanes study, future applications of or updates to the RED Lanes evaluation methodology could benefit from a systemwide context classification analysis.

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[17] http://www.completestreetsnc.org/wp-content/themes/CompleteStreets_Custom/pdfs/NCDOT-Complete-Streets-Planning-Design-Guidelines.pdf

[18] https://connect.ncdot.gov/projects/BikePed/BikePed%20Documents/complete-streets-evaluation-final-report.pdf

INDICATOR | PARKING/CURB SPACE

What is it? Transit passengers board and alight buses along cubs and shoulders meaning buses must draw near to the curb for pickup and drop off at stops. However, on many streets, the curbside lane is also used for on-street parking, loading, access to off-street parking and businesses, ridesharing, and similar purposes. Parking strategies and curb space management policies effect which activities are permitted and during which hours.

Why does it matter? RED Lanes present several potential disruptions or limitations to parking and curb space management strategies. In some cases, RED Lanes may be implemented by replacing existing on-street parking and partially or completely restrict access to the curb. In cases where parking or loading areas need to be retained, an offset RED Lane can provide transit travel time savings and preserve access to the curb in recessed spaces. However, the ingress and egress of parking vehicles or trucks can disrupt bus flow on the offset lane and undermine the operational benefits of the RED Lane. On constrained urban streets with essential on-street parking or curb access needs, a RED Lane may be infeasible regardless of other attributes supporting its implementation.

Offset RED Lanes allow on-street parking spaces to be retained but limit curb access for buses.

How is it measured? Parking and curb space demand are difficult to measure and most measurements address areawide parking supply (number of spaces available), demand (number of spaces needed), and cost. In this report, no regionwide parking measure is provided. However, insight into urban parking policy is discussed based on a recent (2017) City of Raleigh Downtown Development and Future Parking Study[19] (Downtown Parking Study). The parking study offers several notable considerations to guide RED Lane implementation based on parking and curb space needs.

What data and tools are needed? (None)

Findings: Locations of on-street parking are concentrated in downtown Raleigh and in the region's other downtown areas, such as Cary, Wake Forest, Apex, Fuquay-Varina, Zebulon, and Wendell. It is also found sporadically in regional mixed-use centers, such as North Hills and Brier Creek. RED Lane projects in these areas are likely to require detailed consideration of parking supply and demand in project design. Specific considerations vary by location, but the primary themes are encapsulated well by the major components of the City of Raleigh's Downtown Parking Study:

- **Curb Space Management Plan** – This component of the Downtown Parking Study emphasizes block face standardization as a policy approach to providing a consistent, predictable, and comfortable

[19] https://www.raleighnc.gov/services/content/PWksParkingMgmt/Articles/ParkLink.html

user experience of curbside access and activities. On a standardized block face, various uses are grouped together to prevent fragmentation of the curb space. Understanding how a RED Lane supports or disrupts standard block faces will be an import consideration in project development and design.

- **Parking Policies to Support Economic Development** – This component addresses parking policies and pricing strategies to help the City support economic development. In general, parking demand outstrips supply, and augmenting supply is increasingly expensive. New developments are the primary providers of new parking spaces – most of them in off-street decks. Appropriately calibrating parking requirements for developers can help keep development costs competitive while helping the City meet growing parking demand. Additionally, parking strategies should focus on reducing parking demand through increased trip-making by modes that do not require parking, pricing for metered parking, and adopting human-scale community and facility design. RED Lanes support the expansion of transportation options to reduce parking demand. They could also provide opportunities for the City to strategically divest on-street spaces to allow market forces to play a larger role in setting parking rates (a recommendation of the study).
- **Assessment of Current and Projected Future Parking Demand** – This component focuses on current and future parking demand and existing parking supply. As demand outstrips supply over time, the City will likely need to explore strategies focused on structured parking accompanying new private development. Transient parking spaces (many of which are on-street spaces) make up about 19 percent of the parking inventory downtown. Greater shares of transient spaces are likely to be developed in off-street locations as the area's parking inventory expands via structured parking, meaning the loss of on-street spaces for RED Lanes may become more palatable over time, though conditions on specific block faces will vary.
- **Urban Access Policy** – This component offers recommended standards to limit access points for off-street parking. It has limited applicability to RED Lane implementation.

Other notes: (None) While a regionwide inventory of on-street parking is not available to produce a metric for this report, parking considerations remain important in the specific design approaches to a given RED Lane project. Basic inventories of on-street parking along a specific corridor are easily developed, and these can inform how a RED Lane is implemented. In locations where on-street parking is available but demand is limited, the RED Lane could be implemented by taking the parking spaces or imposing time-of-day restrictions on parking. In locations where on-street parking is in high demand, offset RED Lanes with recessed parking should be considered. Where new transient parking is being developed in off-street locations, stakeholder outreach should include careful attention to community preferences related to on-street parking and the evolution of the curb space.

INDICATOR | ACCESSIBILITY

Core Technical Team input
Focus on disadvantaged populations

Priority in evaluation methodology: Medium

What is it? Accessibility is a metric representing the number of destinations that can be reached from a specific geographic point within a region. Accessibility can be tailored to measure the number of total destinations, people, jobs, or specific destination classes that can be reached on a network from a given place and during a set period.

Why does it matter? Accessibility provides a single measure that reflects land development patterns, travel network design and performance, and traveler sensitivities. Accessibility scores by mode can be compared to evaluate travel options and modal competitiveness. By calculating accessibility for different points of origin and accounting for the demographic characteristics of each, accessibility scores can be compared to understand how the transportation system connects different population groups to key destinations in varying degrees. Multimodal accessibility scores are correlated with mode choice decisions, where higher accessibility scores by diverse modes are related to higher shares of multimodal trips.

How is it measured? Travel times from each origin location are calculated to all destination locations using mode-specific travel networks. The activities at each destination location are summarized, applying travel time decay factors to weight nearby activities higher than distant activities to produce the origin location's accessibility score. This process is conducted for all origin locations in a study area and for each mode to be analyzed. For this report, transit and auto access to jobs was measured for each TRM TAZ in the CAMPO region. The measure highlighted for RED Lanes evaluation is the transit-to-auto access ratio (TAR). This measure describes the competitiveness of transit for reaching jobs throughout the region relative to driving.

The CTT expressed particular interest in understanding accessibility for disadvantaged population groups. Therefore, this section also highlights areas demarcated in CAMPO's Title VI, Minority, Limited English Proficiency (LEP), and Low Income Public Outreach Plan[20]. These areas can be overlaid on areas underserved by transit to understand where transit improvements can help meet the needs of disadvantaged populations.

What data and tools are needed? Transit and highway travel skims and TAZ jobs data were obtained from the TRM to conduct the accessibility analysis. CAMPO's Title VI GIS data – tabulated at the block group level – were used to identify areas with disadvantaged population groups. This analysis identified "communities of concern" (CofC's), based on an analysis of Census information. The analysis identified concentrations of the following populations by analyzing Census data at the Block Group level:

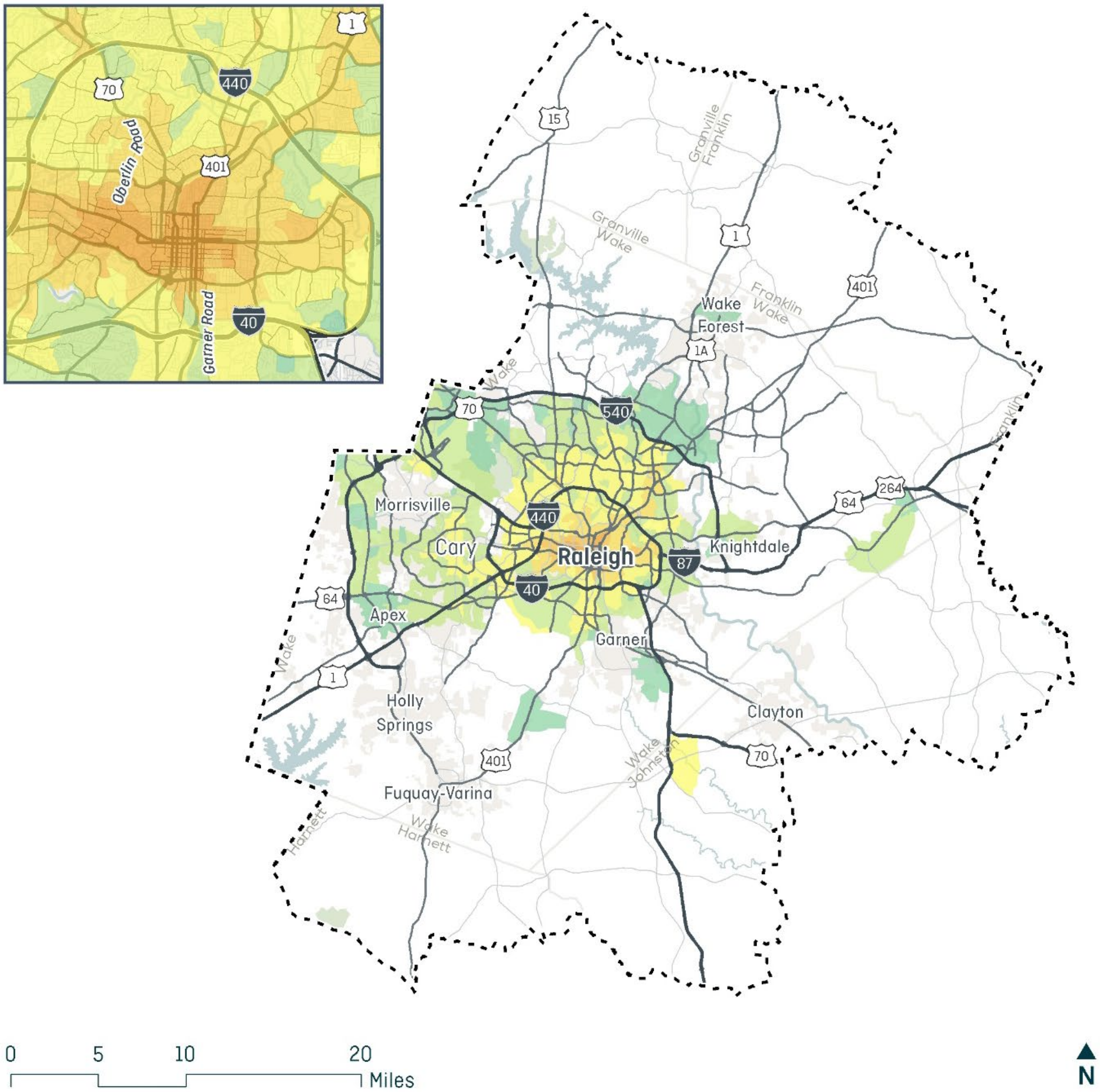
- Non-white race
- Hispanic/Latino origin
- Individuals making less than 150% of the Federal Poverty Rate
- Individuals who speak English "Not at all" or "Not very well"
- Zero-car households
- Individuals Age 70 and older

[20] http://files.www.campo-nc.us/get-involved/public-participation-plan/Title_VI_with_page_numbers_reduced.pdf

CAMPO's Title VI report developed thresholds for each of the six CofC categories. The number of CofC categories that reached the levels identified as part of the study were tabulated for each traffic analysis zone (TAZ) in the Triangle Regional Model (TRM). The composite output of this process is a map that identifies how many of the 6 CofC thresholds were present in each TAZ.

Findings: By reviewing both the transit-to-auto jobs accessibility ratio and CofC maps, it is possible to identify areas in the region where CofC populations are present that have poor access to transit access to jobs relative to auto access to jobs. Notable areas with CofC populations and limited transit accessibility are in the southern and eastern portions of the CAMPO region. These areas are difficult to serve by transit since many are low density areas distant from the urban core. In many urban communities with CofC populations, the TAR scores are relatively strong, although there are sporadic exceptions, notably in the western parts of the region. These zones, however, do not show a confluence of numerous CofC's in underserved transit areas.

RED LANES | EXISTING CONDITIONS - ACCESSIBILITY



Transit Accessibility (TRM 2013)

Transit-to-auto jobs access ratio

0% (unshaded)

0.1% - 2%

2.1% - 5%

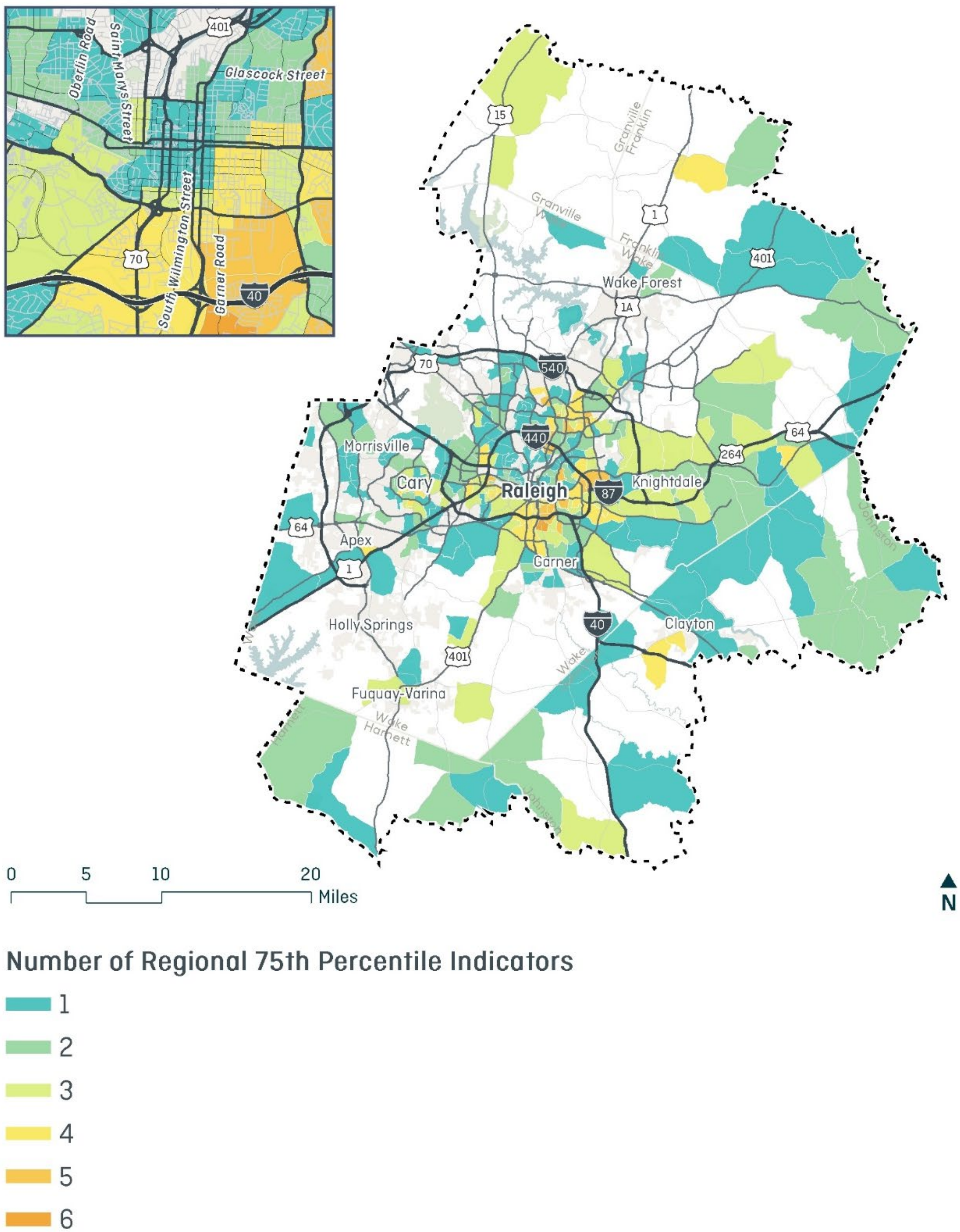
5.1% - 10%

10.1% - 15%

15.1% - 20%

20.1% - 29.3%

RED LANES | EXISTING CONDITIONS - COMMUNITIES OF CONCERN



INDICATOR | FUNCTIONAL/ACCESS CLASS

Core Technical Team input
Priority in evaluation methodology: Low

What is it? Streets and highways are commonly grouped into distinct classes reflecting their roles in the transportation system (functional class) and the appropriate spacing of driveways, signals, median openings, etc. (access class). These classification systems indicate the intended function of a corridor and provide a basic sense of how traffic will flow through the corridor. Higher-order facilities – like expressways – are intended to carry large volumes at traffic at high speeds. Design conventions for these facilities focus on channelization for continuous flow. Access points are few, far between, and appropriately designed to maintain high speed movement. At the other end of the spectrum, lower-order facilities – like minor collectors and local streets – are specifically intended to carry low volumes of traffic at low speeds and provide access to homes, businesses, shopping, attractions, amenities, etc.

Why does it matter? As transit priority improvements, RED Lanes are generally most appropriate on middle tier functional classes. Expressways and major highways often present inhospitable (and in some cases unsafe) environments for transit vehicles making stops, due to the high-speed traffic flowing around the transit vehicle and the uncomfortable pedestrian experience when boarding or alighting the vehicle curbside. However, RED Lanes aim, in part, to keep buses moving through busy corridors, which is at odds with the high-access role fulfilled by local streets and minor collectors. RED Lanes will ideally support the functional roles of the facilities on which they are implemented, meaning arterials and major collectors are generally the most suitable corridors.

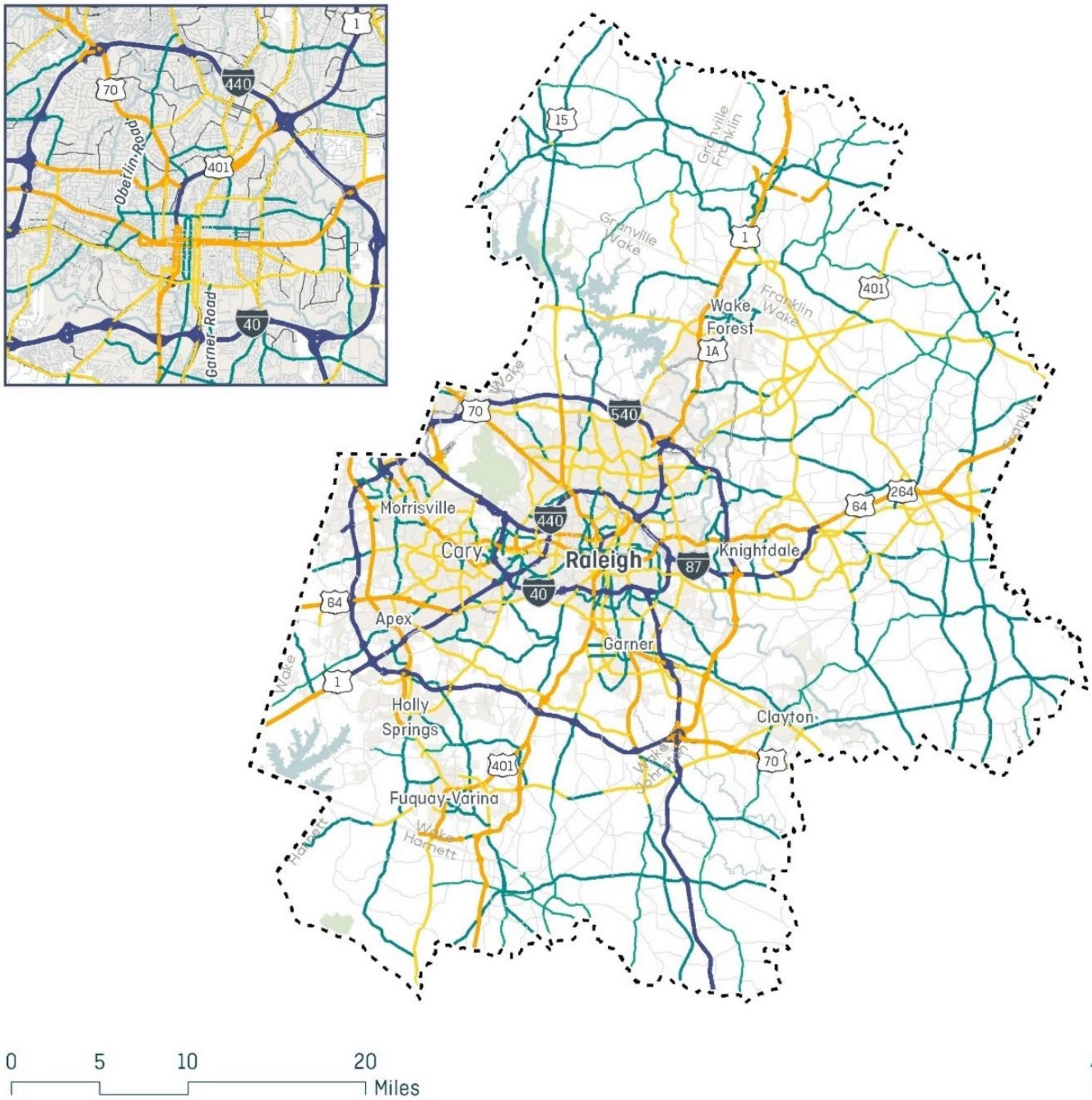
Additionally, a RED Lane includes driveway access and right turns for motorists as part of its core definition. Therefore, RED Lane projects are likely to be most effective in corridors with intermediate-to-frequent spacing of access points and significant numbers of right turns. However, if these are too frequent, the benefits of the RED Lane to transit operations may be undermined.

How is it measured? Functional classes are typically designated by numerical categories where 1 is the highest order facility type focused on inter-regional travel (interstate highways, e.g.) and ascending values reflect an increasingly local orientation. The number of categories varies by system, but the most common include interstate highways, other expressways, principal arterials, minor arterials, major collectors, minor collectors, and local streets.

What data and tools are needed? Functional classifications are available from a variety of sources, all broadly consistent with one another. For this report, functional class designations on the TRM 2045 network are shown to provide insight into the long-term functional class of each corridor.

Findings: Functional classes for the TRM 2045 network are shown in the map below. Most principal arterials are significant commuting corridors. The urban heart of the CAMPO region is served by numerous minor arterials and major collectors with transit service. These are likely to be leading candidates for RED Lanes.

RED LANES | EXISTING CONDITIONS - FUNCTIONAL CLASS



TRM 2045 Highway Network

Functional Class

- Freeways and Expressways
- Principal Arterials
- Minor Arterials
- Major Collectors
- Minor Collectors
- Local

Other notes: As noted above, there are multiple sources and systems for establishing functional class. These include NCDOT Functional Classifications, Federal Functional Class (FFC) from TRM, and Revised Functions Class for NCDOT from TRM. Although the functional classes are not a direct measure of access points (depending on functional classification criteria), limited generalizations can be made per segment classification type. Functional Class is included both independently and with the companion metric of average block size within the TRM TAZ. This supplemental metric provides the potential for additional contextual information leading to a more comprehensive assessment, although it does not reliably reflect access spacing along every road segment within TAZs.

Access class is not singularly tabulated in any of the NCDOT hosted maps in a way that is useful to RED Lanes analysis and therefore is not offered as a separate metric in this study. Opportunities may arise in future iterations of the RED Lanes evaluation methodology to supplement functional classification with access class information. However, it is likely for the foreseeable future that functional class will offer a suitable, readily available metric for understanding the role of a facility in the transportation system and approximating its access characteristics sufficiently to prioritize corridors for RED Lanes investment.

DESIGN

- Number of lanes/lane width/surface width (right-of-way)

TOPIC | DESIGN

Indicators in the Design topic focus on the physical characteristics of a roadway segment. RED Lanes require the dedication of existing space on a roadway segment or the addition of new lanes. Therefore, the Design topic is important in identifying the implementation feasibility of a RED Lane on a given segment.

INDICATOR | NUMBER OF LANES

Core Technical Team input
Focus on available right-of-way

Priority in evaluation methodology: Medium

What is it? The number of lanes, lane width, surface area width, and right-of-way characteristics describe the physical characteristics of a roadway segment and its right-of-way. These measurements are important in identifying the ability for an existing roadway segment to accommodate the addition of a RED Lane, either through expanding a roadway or replacing an existing lane.

Why does it matter? The implementation of RED Lanes typically requires either the dedication of space on an existing roadway or the widening of a roadway segment. The number of existing lanes in each direction provides insight into the capacity for dedicating existing space on a roadway for a RED Lane. The physical dimensions of an existing roadway segments can also be analyzed with building or parcel information to provide insight into the feasibility of expanding a roadway segment to accommodate the addition of a RED Lane. Corridors with limited numbers of lanes (2 in each direction or fewer) and limited opportunities for right-of-way expansion could be screened out or diminished in priority during the RED Lanes evaluation process.

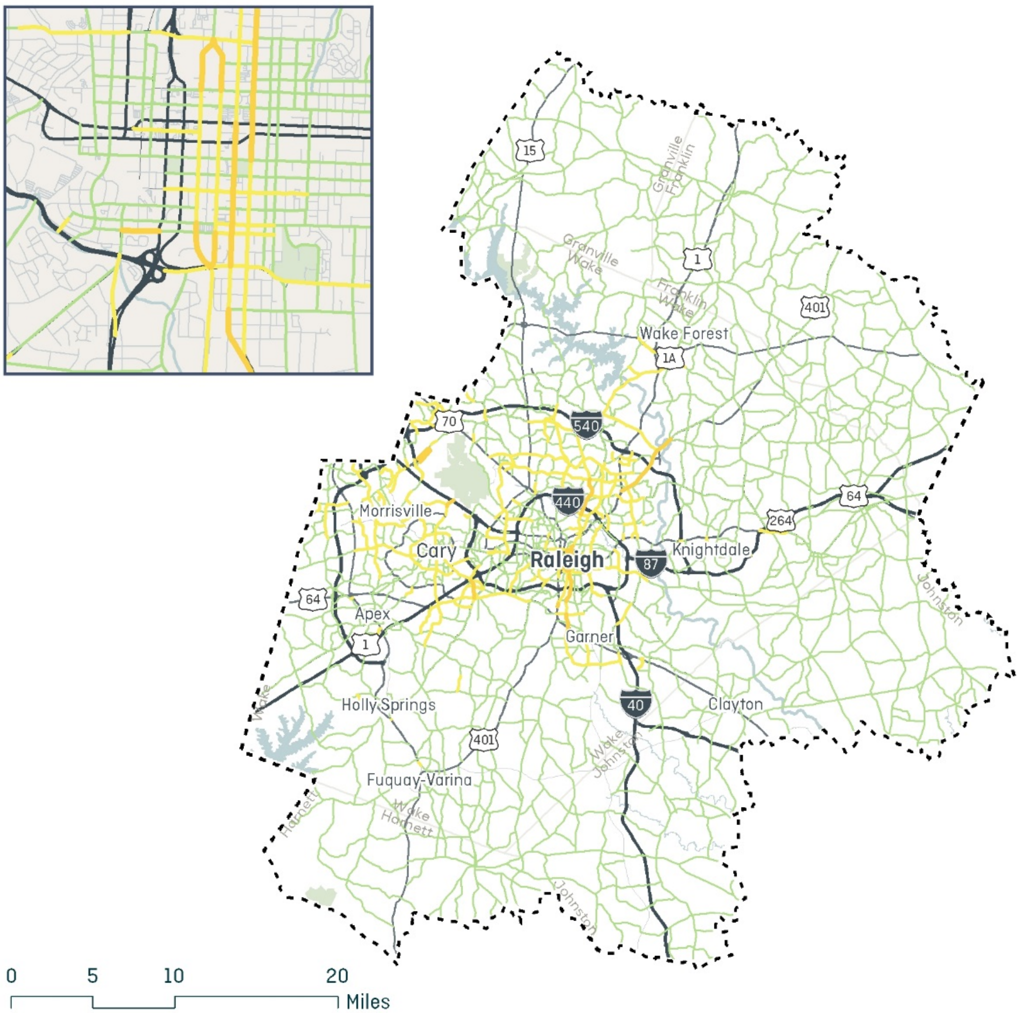
How is it measured? Two metrics were developed to estimate the feasibility of RED Lane implementation. The number of travel lanes in each direction is an effective metric to identify which segments may have capacity to have a lane converted to a RED Lane. The second measure provides a coarse estimate of the feasibility to create RED Lanes by adding a travel lane in each direction on a segment. It expresses the number of existing buildings intersecting a 15-foot buffer either side of each segment on a per mile basis, highlighting areas where right-of-way limitations are most severe.

What data and tools are needed? For the number of lanes measure, the Triangle Regional Model (TRM) existing (2013) network was utilized to calculate the number of through lanes in each direction. This data was selected due to its comprehensive coverage of the study area. Segments designated as freeways were removed since these facilities are not candidates for RED Lanes, allowing surface streets with available lane capacity to feature prominently in mapping.

Different datasets were utilized for the right-of-way feasibility analysis. While precise right-of-way details are difficult to obtain and utilize regionally, the NCDOT roadway characteristics database provides general insight into the existing paved area of most roads and streets, and therefore was used for developing the expansion feasibility analysis metric. This allows a simple GIS analysis of expected roadway dimensions and potential ROW impacts that (a.) assumes additional paved area through the addition of a RED Lane in each travel direction; (b.) highlights segments where such expansions would impact existing buildings or private property boundaries; and (c.) flags segments with the lanes sufficient to potentially incorporate a RED lane by re-purposing existing lane space. Although the NCDOT roadway characteristics database does not contain complete ROW data, an analysis was conducted where data were available. Findings for this indicator are not definitive from a design perspective, but they are a potential screening factor and provide a loose approximation of ROW constraints that could appropriately influence RED Lanes scoring and ranking.

For this analysis, the roadway characteristics dataset was used to estimate the location of the current edge of each existing roadway segment. To do this, the total surface width was divided by two, and added as a dynamic buffer to the existing roadway centerline along with a 15-foot buffer in each travel direction to estimate (estimated based on the addition of one 11-foot travel lane and a 4-foot buffer). This estimated expanded roadway area was then intersected with building footprint polygons from Microsoft's national building footprints dataset. From this analysis, the number of existing buildings that intersect with the estimated expanded roadway buffer was calculated on a per-centerline-mile basis. This process is illustrated in the graphic to the right, which shows the estimated expanded roadway surface areas and the building footprint dataset.

RED LANES | EXISTING CONDITIONS - NUMBER OF LANES



Number of Lanes (Per Direction)

1

2

3+

RED LANES | EXISTING CONDITIONS - RIGHT-OF-WAY ANALYSIS

Buildings Intersected Per Mile — No Data

- 0.0
- 0.1 - 1.0
- 1.1 - 5.0
- 5.1 - 10.0
- 10 +

Findings: The number of lanes on a roadway provides insight into the capacity for existing right-of-way to be utilized for the addition of a RED Lane. Although this dataset is best analyzed jointly with traffic volume and capacity data to identify segments that have both the space and capacity, in general segments with 2 and 3+ lanes have the greatest amount of potential for accommodating a RED lane. Segments with only a single lane would likely need to be expanded. The expansion feasibility analysis provides general planning-level estimates of where roadway expansions could prove to meet the most resistance. In general, the results are intuitive, with the highest rates of intersections with buildings occurring in downtown Raleigh as well as town centers such as Clayton and Garner.

Other notes: While these analyses can provide important estimates for the capacity for a RED Lane to be accommodated by an existing or expanded roadway, it is important to consider the limitations of these analyses. While the number of existing travel lanes provides insight into the capacity for an existing roadway to accommodate a RED Lane, the removal on a full-time or part-time basis of parking is another method to add a RED Lane where volume-to-capacity ratios may not accommodate the removal of an existing travel lane (see "Parking/Curb Space" section above).

INVENTORY OF DATA AND TOOLS

The development of indicators and metrics for this Existing Conditions Report depends on a variety of data sources and a few core analytical tools. This section identifies the key datasets utilized in developing this report in a simple, tabular format (Table 5). The table includes sources for obtaining each dataset, the relevant dates covered by the data, and key information in each dataset for indicator development. The inventory provides an at-a-glance reference for obtaining data to reproduce the indicators described in the "Indicators and Metrics" section. In this way, it also supports future applications of and/or enhancements to the RED lanes evaluation methodology as data are updated.

With future applications in mind, the inventory is organized into two major sections. The upper portion of the table highlights datasets utilized in developing indicators for this report. The lower section identifies potentially useful datasets that could not be operationalized effectively for the current analysis. They are listed here for consideration in potential future enhancements to the RED Lanes evaluation methodology.

Table 5. Inventory of Key Datasets

Dataset	Key Information for Indicator Development
DATASETS USED IN THIS REPORT	
Triangle Regional Model transit lines **Source:** http://www.campo-nc.us/mapsdata/triangle-regional-model **Publication Date:** 2017 **Temporal Scope:** 2013, 2045 **Notes:** Ridership estimates derived from TRM Summary Tool (a separate package that extends the TRM and is available by request from ITRE).	• Daily ridership by route • Peak hour ridership by route
Triangle Regional Model loaded networks **Source:** http://www.campo-nc.us/mapsdata/triangle-regional-model **Publication Date:** 2017 **Temporal Scope:** 2013, 2045 **Notes:** Model outputs include peak period transit speeds (Transit_line.dbd)	• Daily traffic volume • Traffic volume by time of day • v/c ratio by time of day • Free flow speed by time of day • Congested speed by time of day • Functional class • Number of lanes • Estimated bus speed by time of day
Triangle Regional Model zonal data **Source:** http://www.campo-nc.us/mapsdata/socio-economic-data **Publication Date:** 2017 **Temporal Scope:** 2013, 2045 **Notes:** (None)	• Population by TAZ • Employment by TAZ • Total activity (Population + Employment) • TAZ area
Triangle Regional Model travel skims **Source:** Not publicly available. Extracted by staff from TRM. **Publication Date:** 2018	• Origin zone • Destination zone • Travel time by mode

Dataset	Key Information for Indicator Development
Temporal Scope: 2013, 2045 **Notes:** Skims tabulate estimated travel times from origin zones to destination zones by mode.	
ACS Journey to work data **Source:** https://factfinder.census.gov/faces/nav/jsf/pages/download_center.xhtml **Publication Date:** 2018 **Temporal Scope:** 2013 – 2017 (2017 ACS 5-year) **Notes:** (None)	• Commute mode shares by block group
University of Minnesota (UMN) Accessibility Observatory **Source:** http://ao.umn.edu/data/datasets/ **Publication date:** 2015 **Temporal Scope:** 2014 **Notes:** Only covers Wake, Johnston, and Franklin Counties	• Number of jobs reachable by walking within 30 minutes by block
GoRaleigh On-Time Performance by Route **Source:** Direct share from GoRaleigh staff **Publication date:** May 2019 **Temporal Scope:** March 2019 **Notes:** Includes GoTriangle routes operated by GoRaleigh.	• Percent of on-time trip departures and arrivals by route for a 1-month period.
GoCary On-Time Performance by Route **Source:** Direct share from GoCary staff **Publication date:** May 2019 **Temporal Scope:** July-September 2018 **Notes:** Focused on September as a 1-month comparison to GoRaleigh data; on-time performance reported for normal weekday service (holiday and weekend on-time performance ignored).	• Percent of on-time trip departures and arrivals by route for a 1-month period.
NCSU Wolfline known locations contributing to operational delays **Source:** NCSU Wolfline staff direct data share **Publication Date:** May 2019 **Temporal Scope:** 2019 **Notes:** Wolfline routes are variable by semester so consistent route/stop level on-time performance data are difficult to obtain and interpret. Wolfline staff identified consistently problematic locations to support this study.	• Intersections that pose on-time performance issues • Segments that pose on-time performance issues

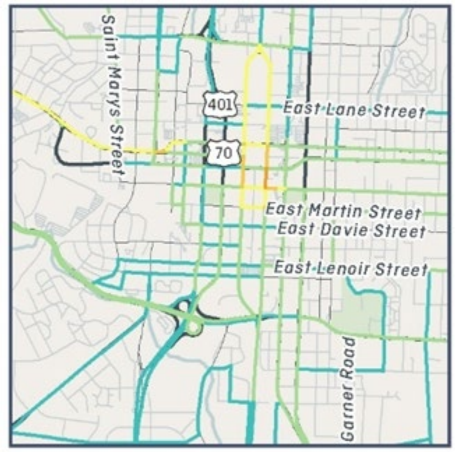
Dataset	Key Information for Indicator Development
GTFS feeds **Source**: https://gotriangle.org/developer-resources **Publication Date:** Q1 2019 **Temporal Scope:** Q1 2019 **Notes:** Includes GoTriangle, GoRaleigh, GoCary, NCSU Wolfline	• Route locations • Stop locations • Current service frequencies by time of day (by route, segment, stop)
Transit Plans GIS Data **Source:** *MTP, Wake Bus Plan, etc. (spatial data consolidated in earlier phases of RED Lanes Study)* **Publication Date**: 2017-2019 **Date:** 2018 - 2045 **Notes:** Consolidated transit line files from various plans	• Planned service frequency by implementation year (2024, 2027, or 2045)
NC enhanced ARNOLD street network **Source:** *Obtained through direct coordination with USDOT staff.* **Publication Date:** 2017 **Temporal Scope:** 2017 **Notes:** For information on ARNOLD, see the FHWA website https://www.fhwa.dot.gov/policyinformation/hpms/arnold.cfm	• *Utilized to work with USDOT tools for locating GTFS route features on a street network.*
Smart Location Database **Source:** https://www.epa.gov/smartgrowth/smart-location-mapping **Publication Date:** 2013 **Temporal Scope: Circa** 2011 **Notes:** The Smart Location Database is a nationwide block-group-level inventory of numerous indicators reflecting built-environment conditions.	• Intersection density by block group (D3bmm4)
NCDOT Roadway Characteristics **Source:** https://connect.ncdot.gov/resources/gis/Lists/DataLayersTextAnnouncements/AllItems.aspx **Publication Date**: Q1 2019 **Temporal Scope**: Q1 2019 **Notes:** Key information listed is not available for all segments.	• Surface width (for right-of-way analysis)
Microsoft Building Footprints **Source**: https://github.com/Microsoft/USBuildingFootprints **Publication date:** 2018 **Temporal Scope:** circa 2016 **Notes:** Building dates depend on ortho imagery dates, which vary throughout the country. Visual inspection of the CAMPO region suggested the vast majority of the current building stock is reflected in this dataset.	• Nationwide building footprint polygons dataset (for right-of-way analysis)

Dataset	Key Information for Indicator Development
CAMPO Title VI Communities of Concern (EJ Block Groups) Map Package **Source:** http://www.campo-nc.us/mapsdata/mtp-data-download **Publication Date:** 2016 **Temporal Scope**: circa 2012 **Notes:** (None)	• Community of concern Title VI indicators by block group
DATASETS FOR CONSIDERATION IN FUTURE UPDATES TO RED LANES EVALUATION METHODOLOGY	
HERE Traffic Analytics or similar **Source**: https://www.here.com/products/traffic-solutions/road-traffic-analytics **Notes:** Vendor data	• Average historical speed by segment
LODES OD data **Source:** https://lehd.ces.census.gov/data/ **Notes:** 2015 is most current year available at time of writing	• Commute origin-destination patterns by block or higher level of aggregation
Transit Agency APC data or other usage/reliability information **Source:** Direct share from agencies **Notes:** Stop-level boarding and alighting activity could support more robust segment level transit ridership analysis.	• Stop boarding/alighting activity • Headway adherence • Travel time degradation
NC OneMap Parcel Data **Source:** http://data.nconemap.gov/downloads/vector/parcels/ **Notes:** Fine-grained parcel data could allow more robust exploration of adjacent land uses and/or support a context classification analysis that could inform RED Lane design choices.	• Parcel boundaries • Building square footage • Land use category supporting LU diversity analysis

The data listed in Table 5 are generally available from national, state, or local/regional sources. In some cases, coordination with agencies generating the data may be required to obtain specific datasets. Mapping and analyzing diverse datasets requires GIS software, such as ArcGIS. Generating metrics from the Triangle Regional Model (TRM) requires TransCad software and TRM input and setup files. Some of the processing steps used to generate measures for this report utilize Python scripts and require a basic knowledge of how to edit and run a script to re-create the analyses presented here.

CANDIDATE CORRIDORS

In the development of candidate corridors, the indicators summarized in this report are presented at segment, corridor/route, and zone levels. These indicators are intended to support the RED Lanes evaluation process at a segment level to differentiate segments and corridors in terms of their suitability for RED Lanes implementation.



Existing transit service Frequency in central Raleigh

While this level of evaluation is appropriate for the purposes of the RED Lanes study, it is also valuabe to consider individual corridors within the context of neighboring corridors. In some cases, one single corridor by itself may not appear to have attributes needed to support a RED Lane. However, a re-alignment of one or more routes onto a roadway might be bring about levels of service and ridership that support RED Lane implementation. Opportunities like this are most likely to occur in more dense areas with higher levels of transit service, such as downtown Raleigh. For example, Wilmington Street, Person Street, and Blount Steet are one-way facilities with modest existing transit service frequency. If RED Lanes were implemented on Blount Street, including a contra-flow lane, buses using any of the three corridors could be funnelled onto Blount.[21] Keeping this in mind, application of the RED Lanes tool could include scenario testing to allow the affects of re-routing services along RED Lanes corridors to influence corridor suitability for project development purposes. In this way, RED Lanes candidate corridors could potentially include corridors with no existing or planned transit service that represent opportunities for service consolidation.

The development of the RED Lanes Evaluation Methodology will likely highlight additional candidate corridors beyond those presented in the *Key Plans in the CAMPO Region* report.

The next phase of the RED Lanes Study is the development of the RED Lanes Evaluation Methodology. The methodology will be focused on prioritizing corridors across the region for RED Lanes, highlighting those that are most suitable based on existing conditions and trends as presented in this report. The appropriate use and weighting of each indicator is part of the focus of CTT Workshop #2 (June 27, 2019) and will be tested and revised during the next phases of the study. Some indicators presented here may not be utilized in corridor prioritization but will be retained to appropriately guide RED Lane project design and implementation strategies on high priority corridors.

[21] This is hypothetical proposition for illustrative purposes. Prioritization of RED Lanes and suggested implementation strategies and design approaches for select corridors will emerge during a later phase of the RED Lanes study.

REPORT 4: RED LANES EVALUATION METHODOLOGY

RED Priority Bus Lanes Study

RED Lanes Evaluation Methodology

June 2020

CAMPO
NC Capital Area Metropolitan Planning Organization

RENAISSANCE PLANNING

wsp

CONTENTS

1 OVERVIEW – OBJECTIVES AND APPROACH

OBJECTIVES

For a given location, assign a value that reflects its suitability for RED Lanes, differentiated by travel demand, transportation system operations, and area design/context characteristics.

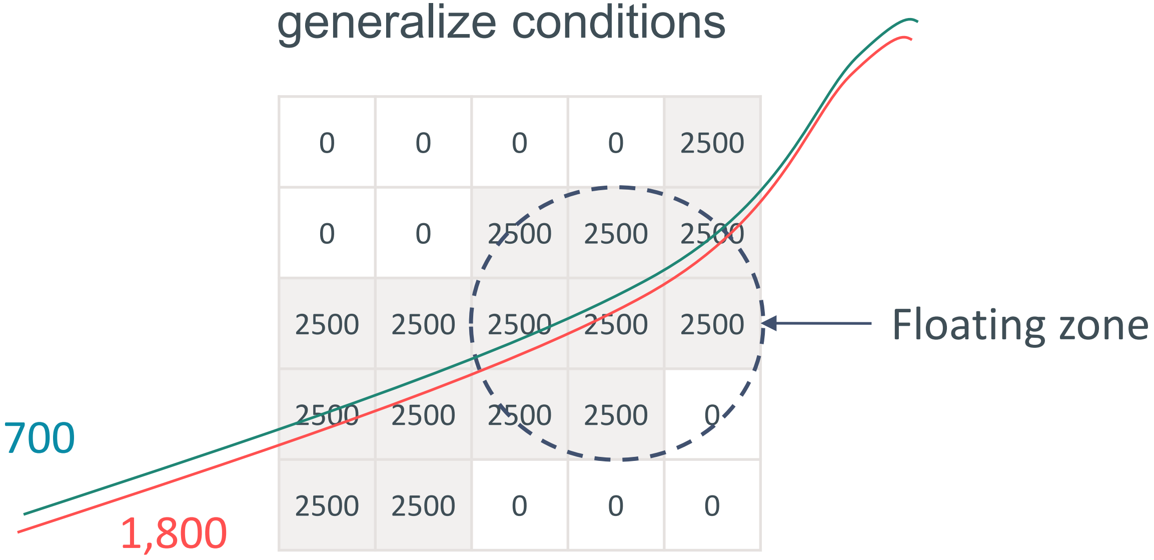
1. Major dimensions of RED Lanes suitability.
   - Travel demand
   - Transit operations
   - Highway operations
   - Contexts and design
2. Analyze conditions on an “areawide” basis to address inconsistencies in the details of line geometries.
3. Create a consistent, predictable, and replicable process.
   - Facilitate testing of measures
   - Simplify updates to accommodate new/fresh data
   - Allow CAMPO and partner agencies to engage with and revise the RED Lanes Suitability process

APPROACH – DIMENSIONS

1. Major dimensions of RED Lanes suitability.
   a. Identify data sources and potential measures that define and describe these dimensions.
      - Reference earlier study reports for recommended measures.
        - RED Lanes Fundamentals
        - Existing Conditions Report
      - Utilize feedback from CTT workshops to set weighting of variables in the suitability analysis process.

APPROACH – METHODS FOR MEASURING DIMENSIONS

2. Account for areawide conditions when measuring each dimension.
    a. Utilize spatial analysis to estimate typical conditions in a given area revealed by various linear datasets.
        - Since not all lines are digitized consistently, it is important to consider all lines within a small area to combine measures from diverse datasets.
        - Define "floating zones" as areas for which all available data points will be aggregated to generalize conditions



The blue line and the red line represent the same facility but have inconsistent GIS representation.

The blue line shows 700 transit riders on route A; the red 1,800 riders on route B.

The total ridership within the floating zone is… 2,500.

APPROACH – STREAMLINING PROCESSES

3. Create a consistent, predictable, and reliable process.
   a. Utilize standard geo-processing tools to develop measures.
      - ArcGIS's Spatial Analyst extension
   b. Develop scripted process to sequence geo-processing tasks and minimize the effort required to (re)run, modify, and update suitability estimates
      - Python (arcpy)
   - Provide a simple interface for ease of use
      - ArcMap geoprocessing script interfaces

APPROACH FOR DATA DRIVEN RED LANES SUITABILITY

- Quantitatively assess suitability “tier”
  - Travel demand
  - Transportation system operations
  - Contexts
- “Tiers” are scaled from 0 (no suitability) to 10 (max suitability)
- Qualitatively embellish tiers with additional information
  - Peak-hour vs full-time RED Lanes (full time suitability)
  - TSP suitability
  - Non-motorized demand
  - Design constraints/feasibility
  - Communities of Concern served

RED LANES FUNDAMENTALS – BEST PRACTICES FOR PLANNING

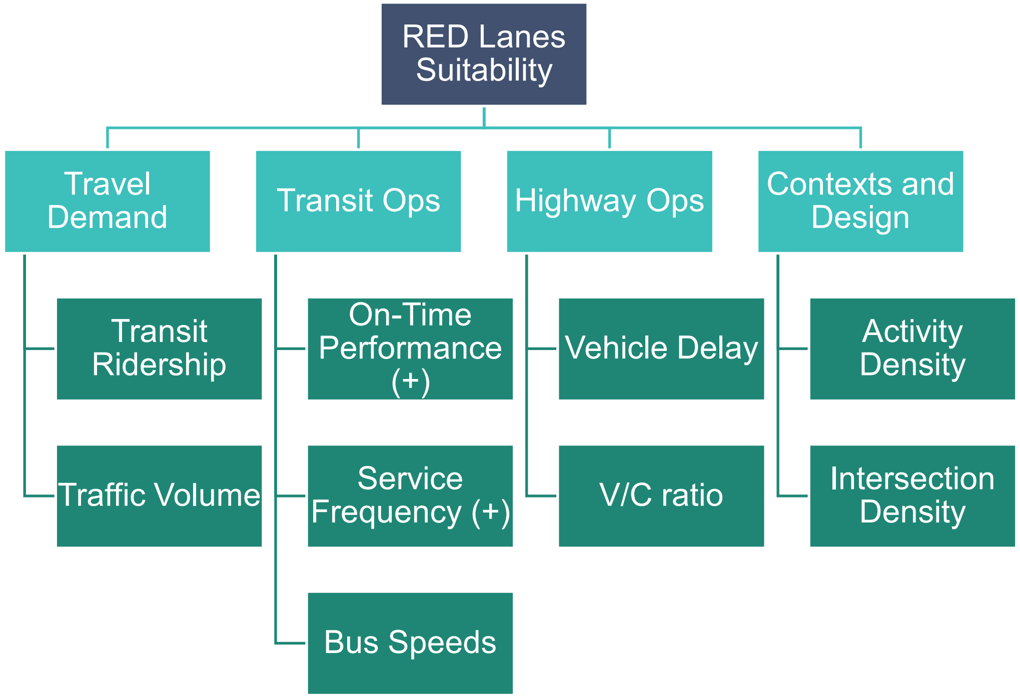
- Commonly cited key metrics listed in RED Lanes Fundamentals Report.
  - Transit vehicle volume
  - Person throughput by all modes
  - Volume-to-capacity (v/c) ratio and highway level of service
  - Reliability, travel time variability, delay
  - Safety
  - Available right of way and physical/spatial constraints
- Each of these measures (except safety) was addressed in the Existing Conditions Report (ECR).
  - The ECR measures are being used as inputs to the suitability analysis.
  - Safety will be assessed for priority corridors as a consideration informing appropriate RED Lane design.

ECR MEASURES BY TOPIC

- Hierarchical approach
  - Topics help create natural groupings of measures such that distinctive dimensions of RED Lanes suitability can be assessed using a small collection of variables.
  - Once each dimension has been assessed, they can be combined/overlaid to understand the complete picture of RED Lanes suitability.
  - Some factors are better utilized for implementation guidance rather than suitability analysis. These can be operationalized in the same way.

TOPIC AREA Indicator	Metric	CTT Priority	Literature Priority
DEMAND			
Transit Ridership (p. 8)	Forecasted daily route-level transit passengers by segment in 2045	High	High
	Forecasted peak-hour route-level ridership as a share of daily route-level ridership by segment in 2045	High	High
Transit Mode Share (p. 12)	Transit commute (journey to work) mode share in 2015	Low	Low
Traffic Volume (p. 14)	Forecasted daily bi-directional traffic volume by segment in 2045	Low	High
	Forecasted PM peak hour volume-to-capacity ratio by direction in 2045	Low	Medium
Non-motorized Users (p. 18)	Walk access to jobs (proxy for non-motorized trip demand) in 2014	Low	Low
Person throughput *(p. 20)*	*To be addressed at a project level*	*High*	*High*
OPERATIONS			
Transit on time performance/reliability (p. 21)	On time performance rates by route in 2018/19	High	High
Transit service frequency (p. 25)	Transit vehicles per hour (bi-directional) by segment in 2019	Low	High
	Future RED Lanes-supportive frequency by segment by planning horizon year.	Low	High
Transit Signal Priority *(p. 29)*	*To be addressed at a project level*	*Medium*	*NA*
Person/vehicle delay (p. 30)	Forecasted AM peak hour congested-to-free-flow-speed ratio by direction in 2045	Low	Medium
Average travel speed (p. 33)	Forecasted peak hour bus travel speed by direction in 2045	Low	Medium
CONTEXTS			
Adjacent land uses (p. 35)	Activity unit density by TAZ in 2013	Medium	Low
	Intersection density by block group in 2011	Medium	Low
Context classification/ complete streets (p. 39)	*To be addressed at a project level*	*Medium*	*NA*
Parking/curb space (p. 41)	*To be addressed at a project level*	Low	Low
Accessibility (p. 43)	Transit-to-auto access to jobs ratio in 2013	Medium	NA
	Communities of concern by block group in 2012	Medium	Low
Functional/access class (p. 47)	Functional class by segment in 2045	Low	Low
DESIGN/OTHER			
Number of lanes (p. 50)	Segment lane count by direction in 2013	Medium	Medium
	Buildings intersected (within potential ROW buffer) per mile by segment in 2018	Medium	Medium
Intersection design, separation of traffic, safety, enforcement, maintenance, cost, and project length to be addressed at a project level, following best practices findings from RED Lanes Fundamentals *report.*			

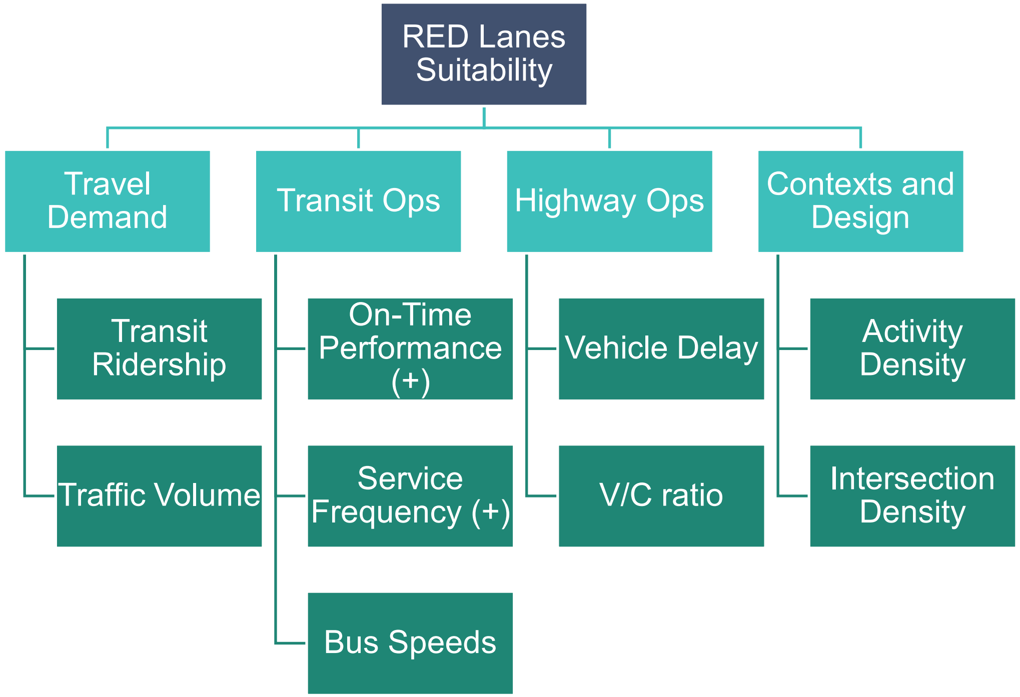
DATA DRIVEN PRIORITIZATION BASED ON DATA DEVELOPED IN ECR



Combine the ECR measures into a holistic understanding of suitability and implementation guidance (this section focuses on suitability).

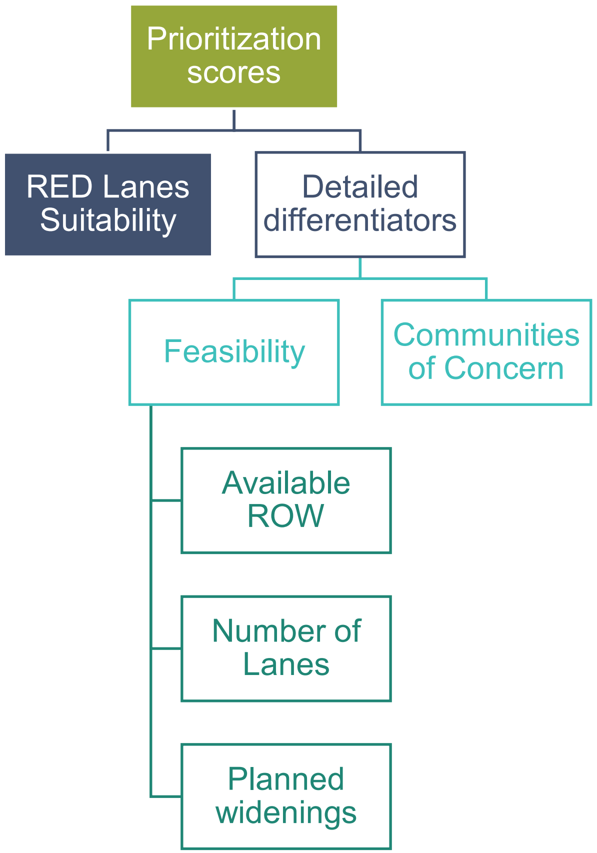
- Hierarchically address key dimensions of suitability
    - Travel Demand
    - Transit Operations
    - Highway Operations
    - Contexts and Design

TRAVEL DEMAND ANALYSIS



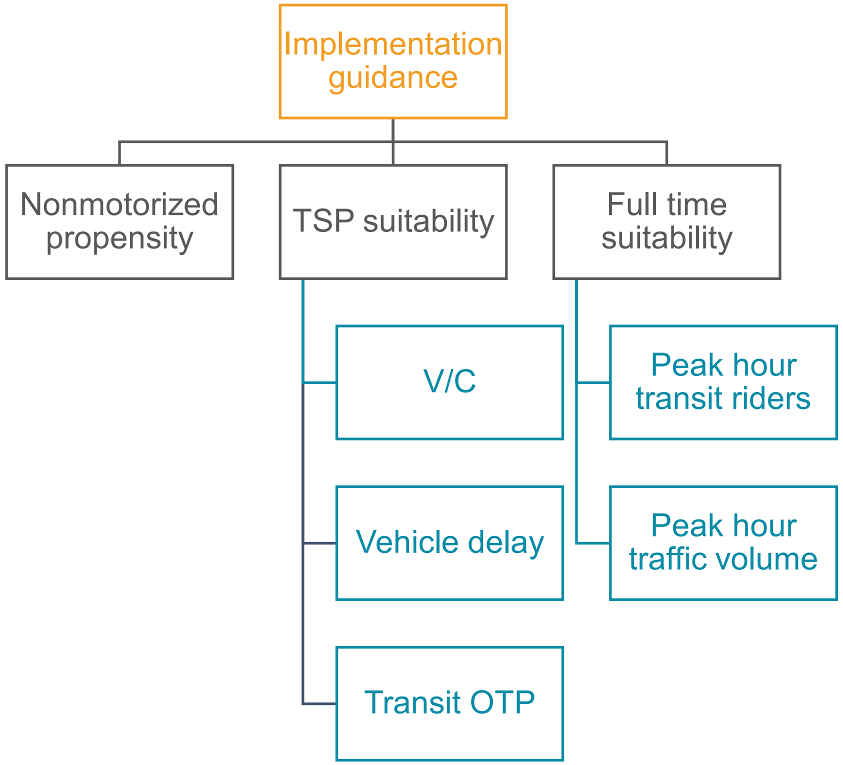
- Assess expected suitability tier on a dimension-by-dimension basis
- Overlay all dimensions to determine tier based on combined measures
  - Weight each dimension's influence on final suitability score
- Embellish raw suitability score with other scores derived using the same approach.

DATA DRIVEN PRIORITIZATION BASED ON DATA DEVELOPED IN ECR



- Enrich raw suitability scoring with other measures
- Some variables provide detailed differentiation among segments with similar RED Lanes Suitability scores
  - Feasibility – segments with adequate ROW, suitable number of lanes, or planned widenings
  - Communities of concern – segments serving neighboring areas with transportation disadvantaged populations.

DATA DRIVEN PRIORITIZATION BASED ON DATA DEVELOPED IN ECR



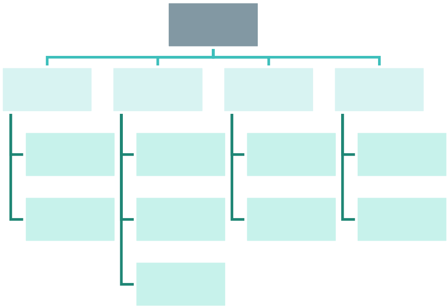
- Enrich raw suitability scoring with other measures
- Implementation guidance
  - Measures indicating how a RED Lane should be designed/implemented.
  - These are generated by the tool but not incorporated in the corridor ranking

2

WALKTHROUGH OF SUITABILITY ELEMENTS

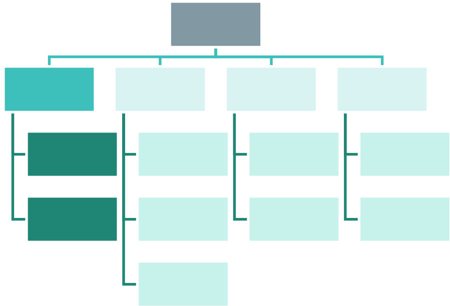
WALKTHROUGH OF SUITABILITY ELEMENTS

- The following slides provide details of how each component of the RED Lanes Suitability process is developed, including data sources, analysis parameters, scoring rubrics and maps.
- The diagram in the lower left corner indicates which components of the scoring process are depicted in each slide.



TRAVEL DEMAND – SCORING DIMENSIONS

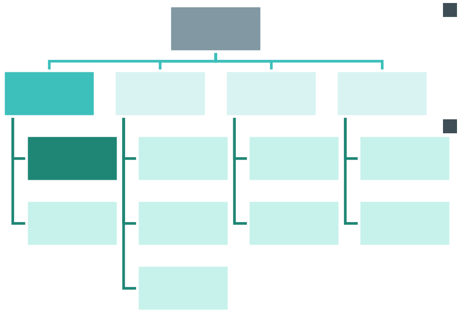
- Measures:
  - Forecasted (2045) Daily Transit Ridership
  - Forecasted (2045) Daily Traffic Volume



TRAVEL DEMAND – TRANSIT RIDERSHIP

Measure: Daily Transit Ridership

- Rationale:
  - RED Lanes are most effective in high ridership corridors, providing transit travel time savings to the greatest number of users.
  - Daily demand reveals overall utilization of the corridor by transit patrons. Peak-hour ridership will be considered for full-time vs. part-time implementation considerations.
- Sources:
  - TRM transit ridership forecasts (2045) – forecasts are available at a route level rather than a segment level.
- Methods:
  - For a defined floating zone area, summarize the daily transit ridership on routes using an adjacent facility.
  - Define thresholds to set “suitability tiers” based on ridership forecasts

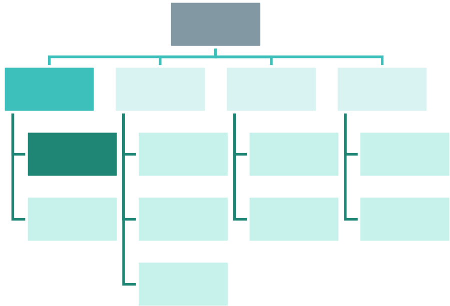


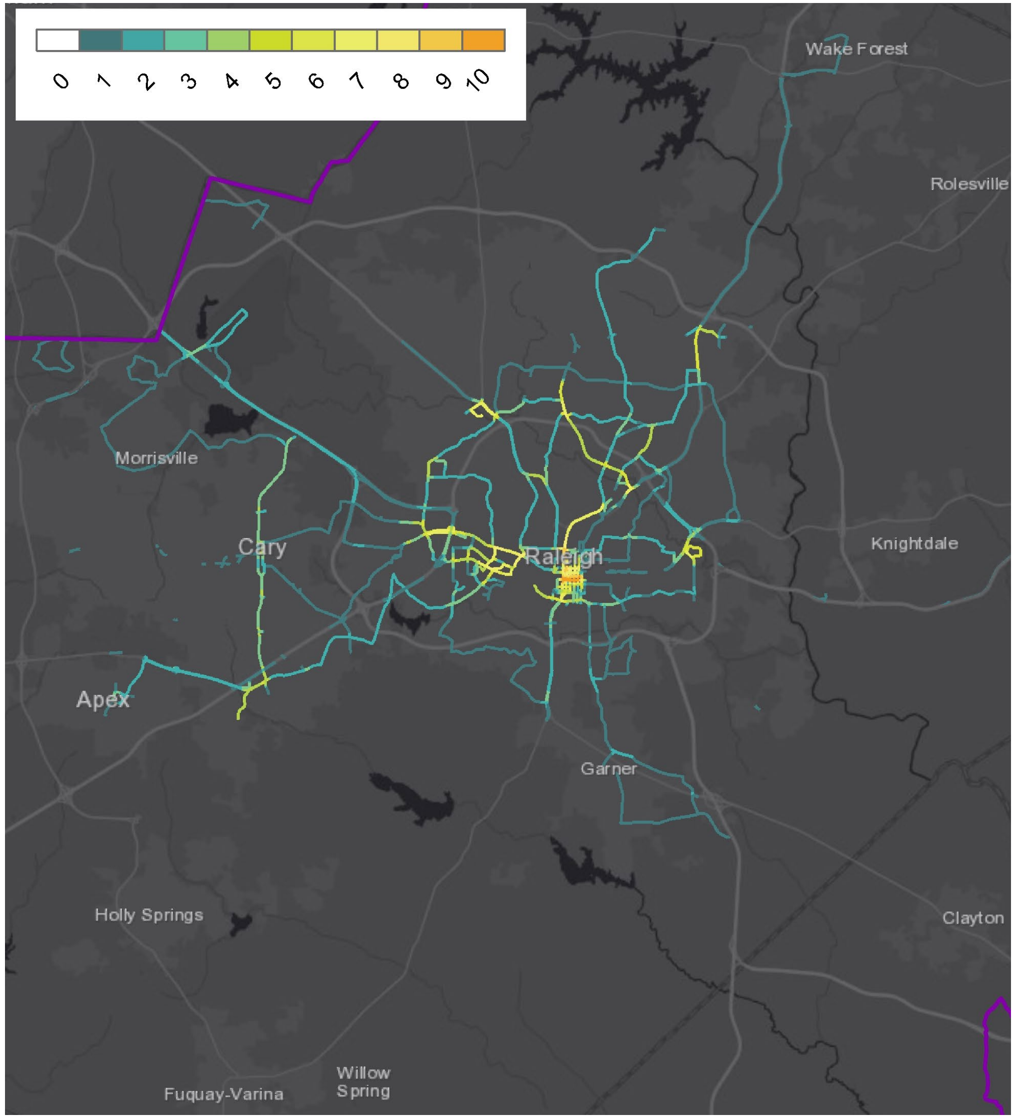
TRAVEL DEMAND – TRANSIT RIDERSHIP

Measure: Daily Transit Ridership (2045)

- Analysis specs:
  - Floating zone: Circle with 200' radius

Ridership Range	Suitability Score
0 – 1,000	1
1,000 – 2,500	2
2,500 – 4,000	3
4,000 – 6,000	4
6,000 – 8,000	5
8,000 – 10,000	6
10,000 – 15,000	7
15,000 – 20,000	8
20,000 – 35,000	9
35,000+	10

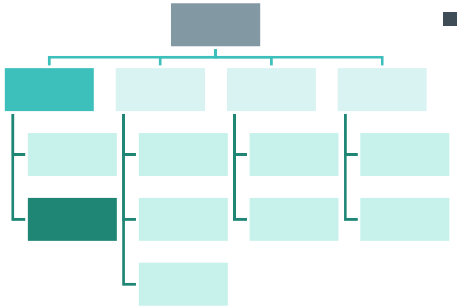




TRAVEL DEMAND – TRAFFIC VOLUME

Measure: Daily Traffic Volume

- Rationale:
    - RED Lanes should facilitate timely connections along well-traveled corridors, enhancing multimodal options for the greatest number of travelers.
    - Daily demand reveals overall utilization of the corridor. Peak-hour demand will be considered for full-time vs. part-time implementation considerations.
- Sources:
    - TRM traffic forecasts (2045)
- Methods:
    - For a defined floating zone area, summarize the daily traffic volume on an adjacent facility (exclude limited access highways).
    - Define thresholds to set “suitability tiers” based on traffic volume forecasts

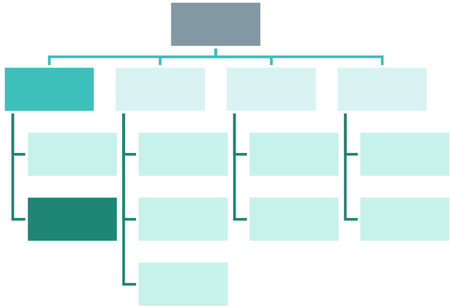


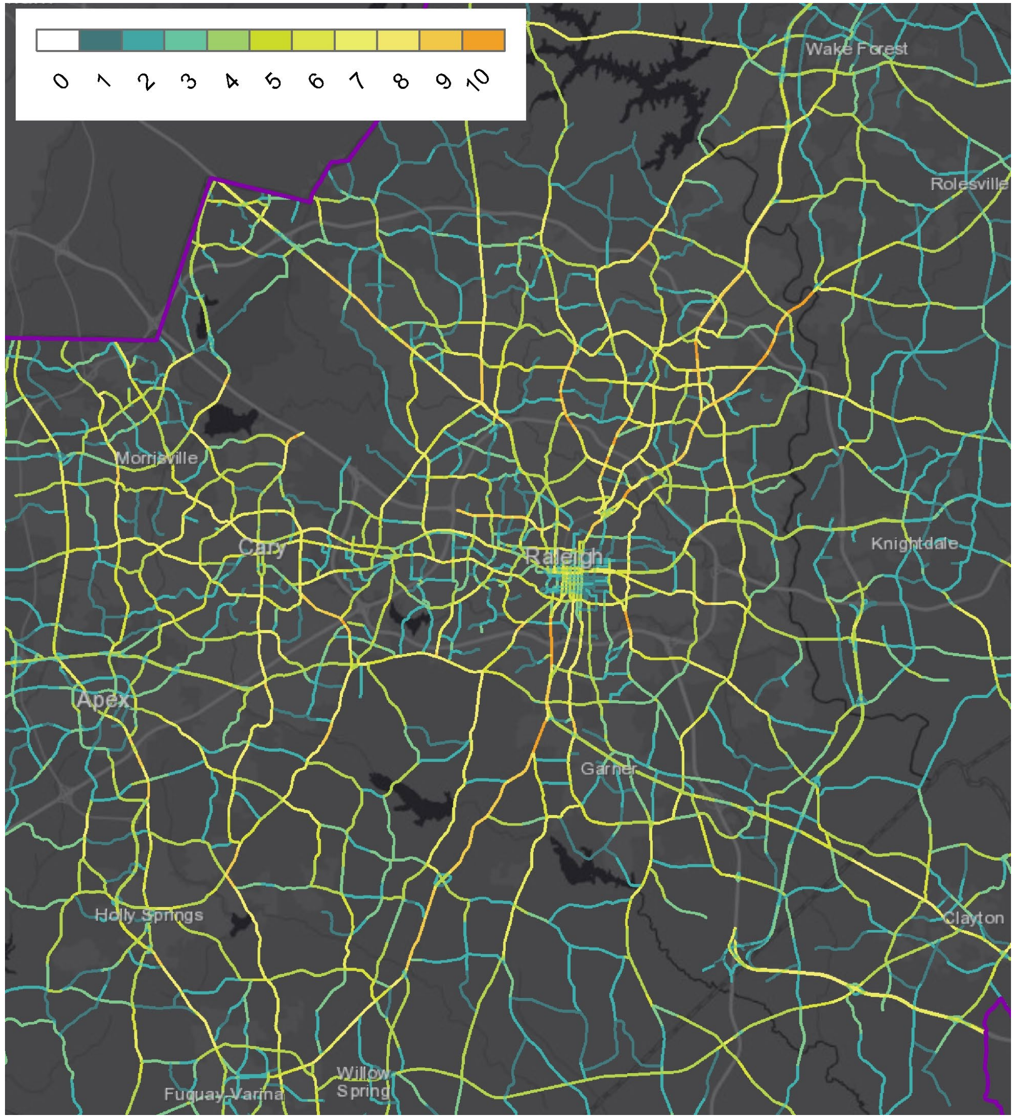
TRAVEL DEMAND – TRAFFIC VOLUME

Measure: Daily Traffic Volume (2045)

- Analysis specs:
  - Floating zone: Circle with 200’ radius

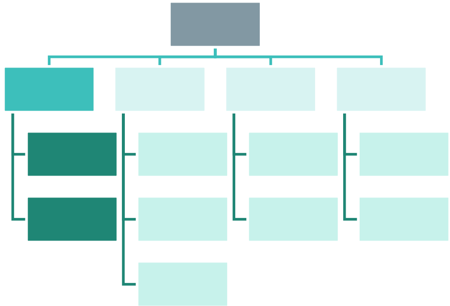
Volume Range	Suitability Score
0 – 5,000	1
5,000 – 10,000	2
10,000 – 15,000	3
15,000 – 20,000	4
20,000 – 25,000	5
25,000 – 30,000	6
30,000 – 40,000	7
40,000 – 50,000	8
50,000 – 70,000	9
70,000+	10

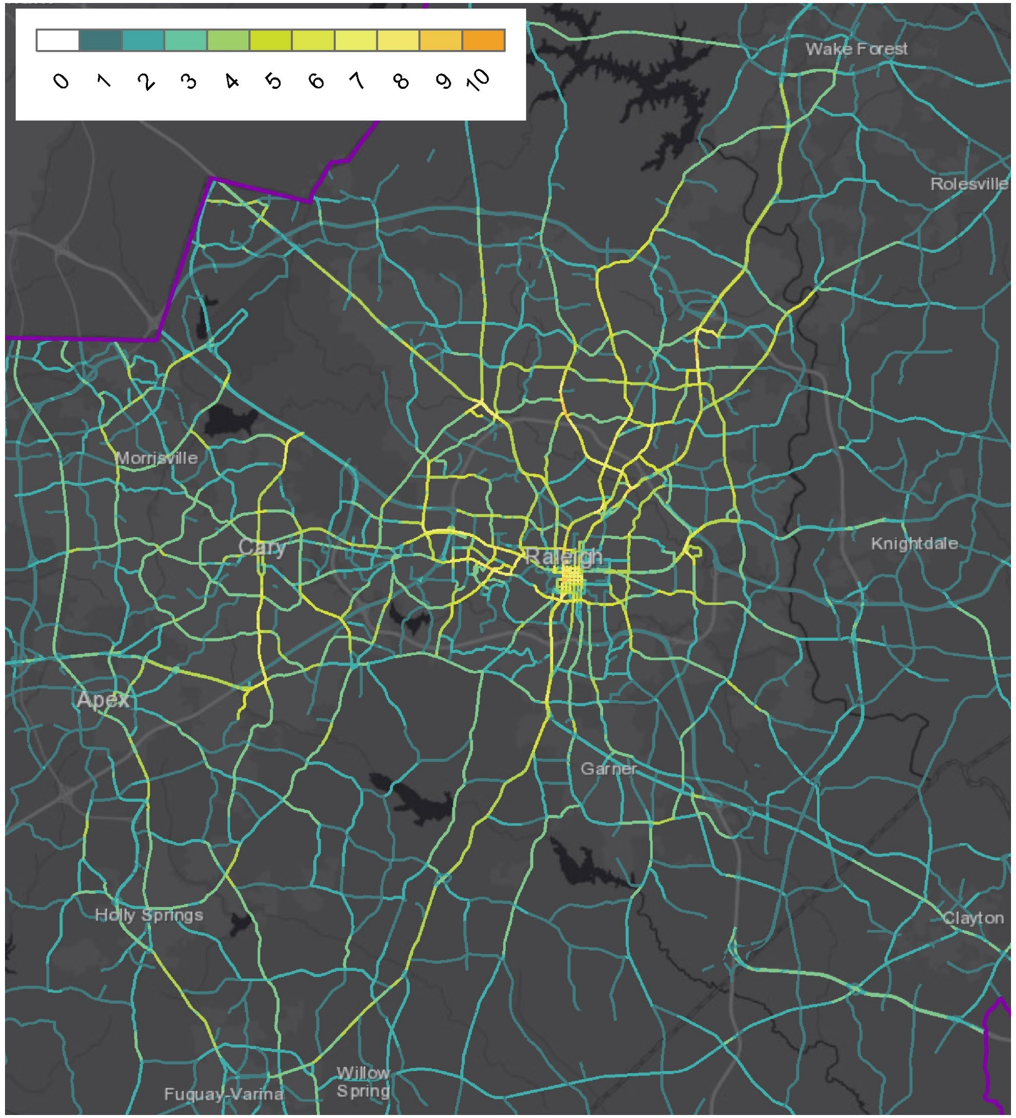




Measure: Travel Demand Suitability

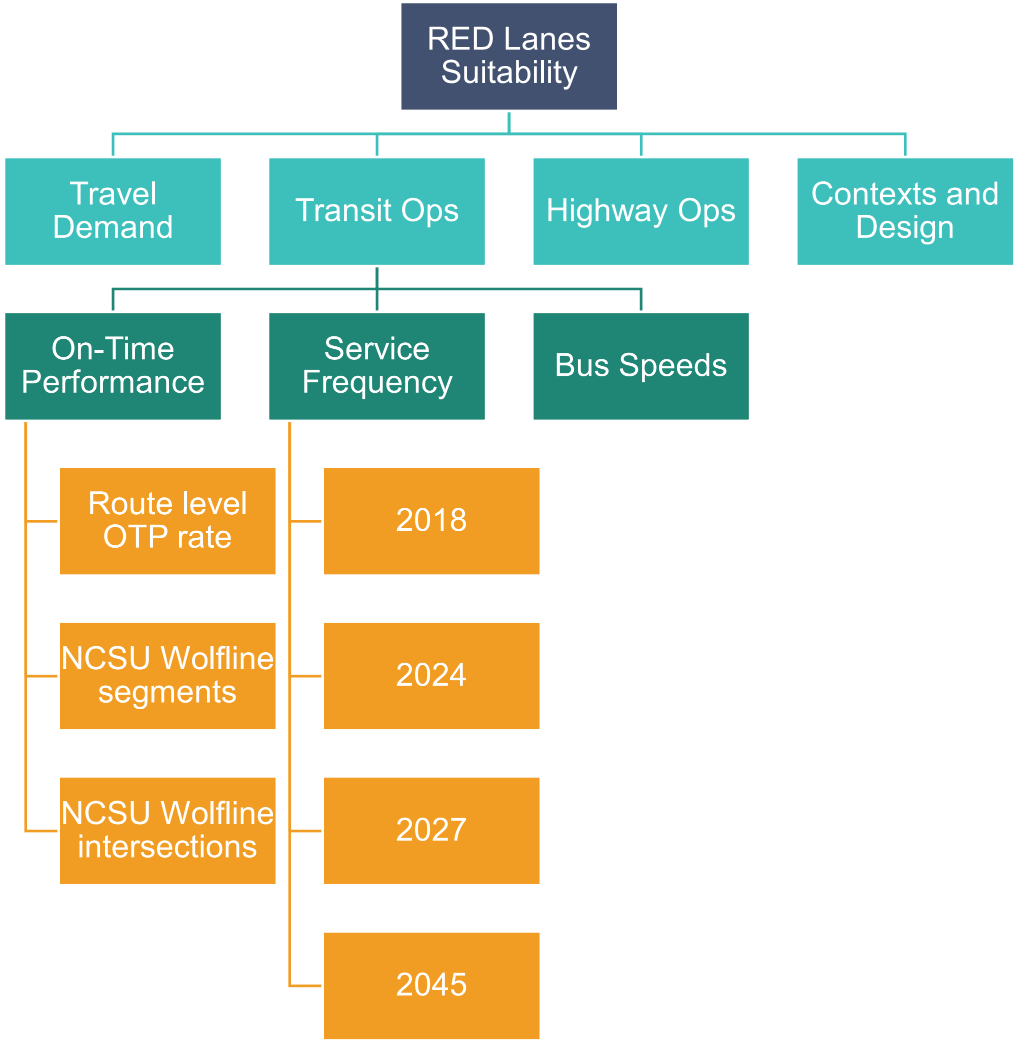
- Methods:
  - Overlay the transit ridership and traffic volume suitability maps and take a weighted average.
    - Transit ridership weight: 60%
    - Traffic volume weight: 40%

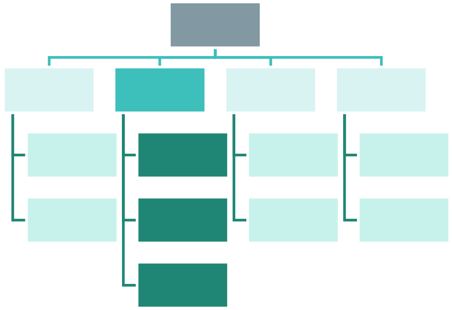




TRANSIT OPERATIONS – SCORING DIMENSIONS

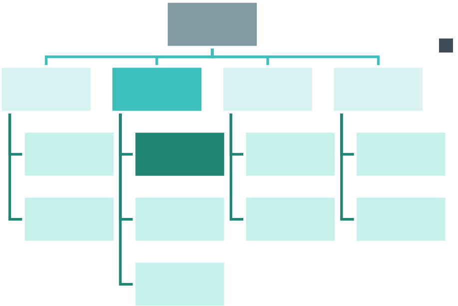
- Measures:
  - On-Time Performance
  - Service frequency
  - Transit travel speed





Measure: On-Time Performance (OTP)

- Rationale:
  - RED Lanes provide more consistent travel conditions for transit vehicles, helping alleviate schedule adherence issues.
- Sources:
  - Route-level OTP statistics from transit agencies.
  - Segments that pose on-time performance difficulties for NCSU routes.
  - Intersections that pose on-time performance difficulties for NCSU routes.
- Methods:
  - For a defined floating zone area, summarize the average route-level OTP rate.
  - Define thresholds to set “suitability tiers” based on OTP rates.
  - Combine route-level OTP tiers with NCSU flagged features.



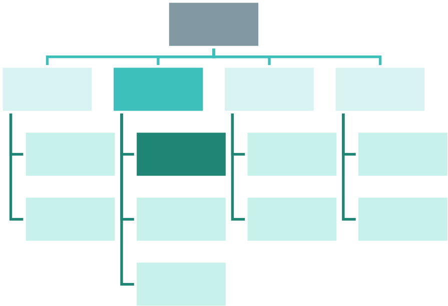
TRANSIT OPERATIONS – ON-TIME PERFORMANCE

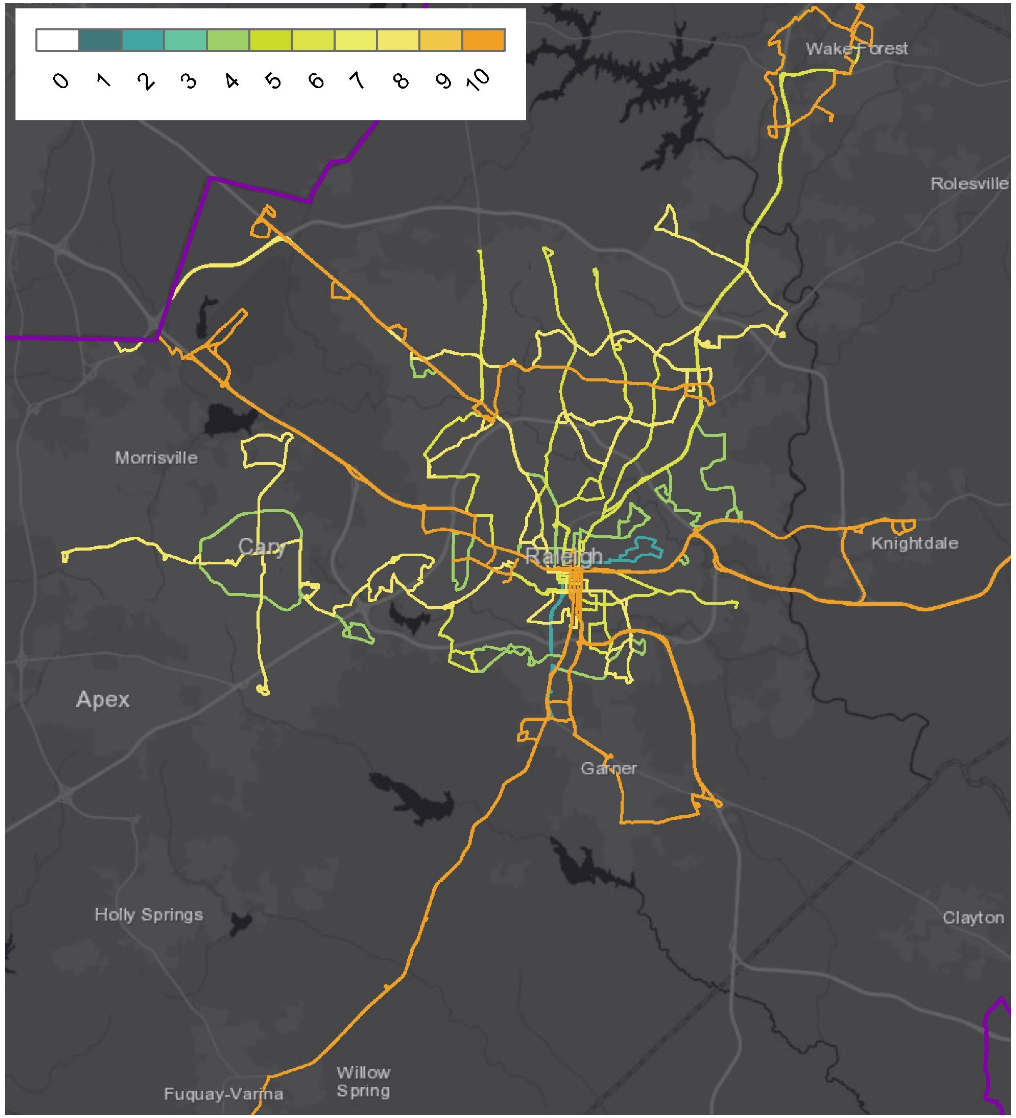
Measure: On-time performance (c. 2019)

- Analysis specs:
  - Floating zone: Circle with 200' radius

OTP rate	Suitability Score
0 – 75%	10
75% - 80%	8
80% - 85%	6
85% - 90%	4
90%- 95%	2
95% - 100%	0
If NCSU segment*	10
If NCSU intersection*	10

*Segments and intersections identified by Wolfline staff as posing reliability issues.

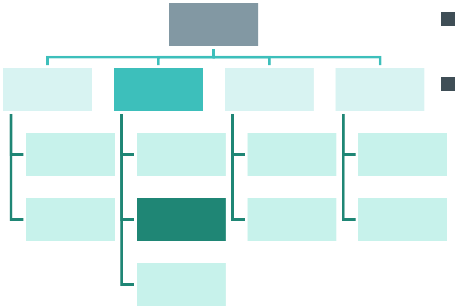




TRANSIT OPERATIONS – SERVICE FREQUENCY

Measure: Service Frequency

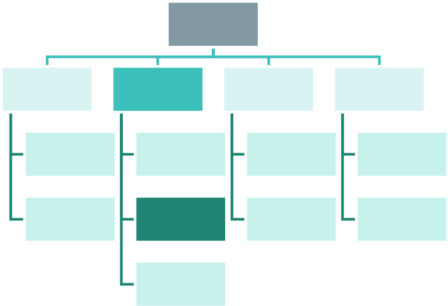
- Rationale:
  - RED Lanes are most effective on segments with frequent bus service, justifying the designation of the priority lane and making the lane effectively self-enforcing.
- Sources:
  - Wake Bus Plan routes and headways
  - MTP routes and headways
- Methods:
  - For a defined floating zone area, summarize the total buses per hour in the peak period (by horizon year).
  - Define thresholds to set “suitability tiers” based on frequency.
  - Overlay existing and planned service frequencies.



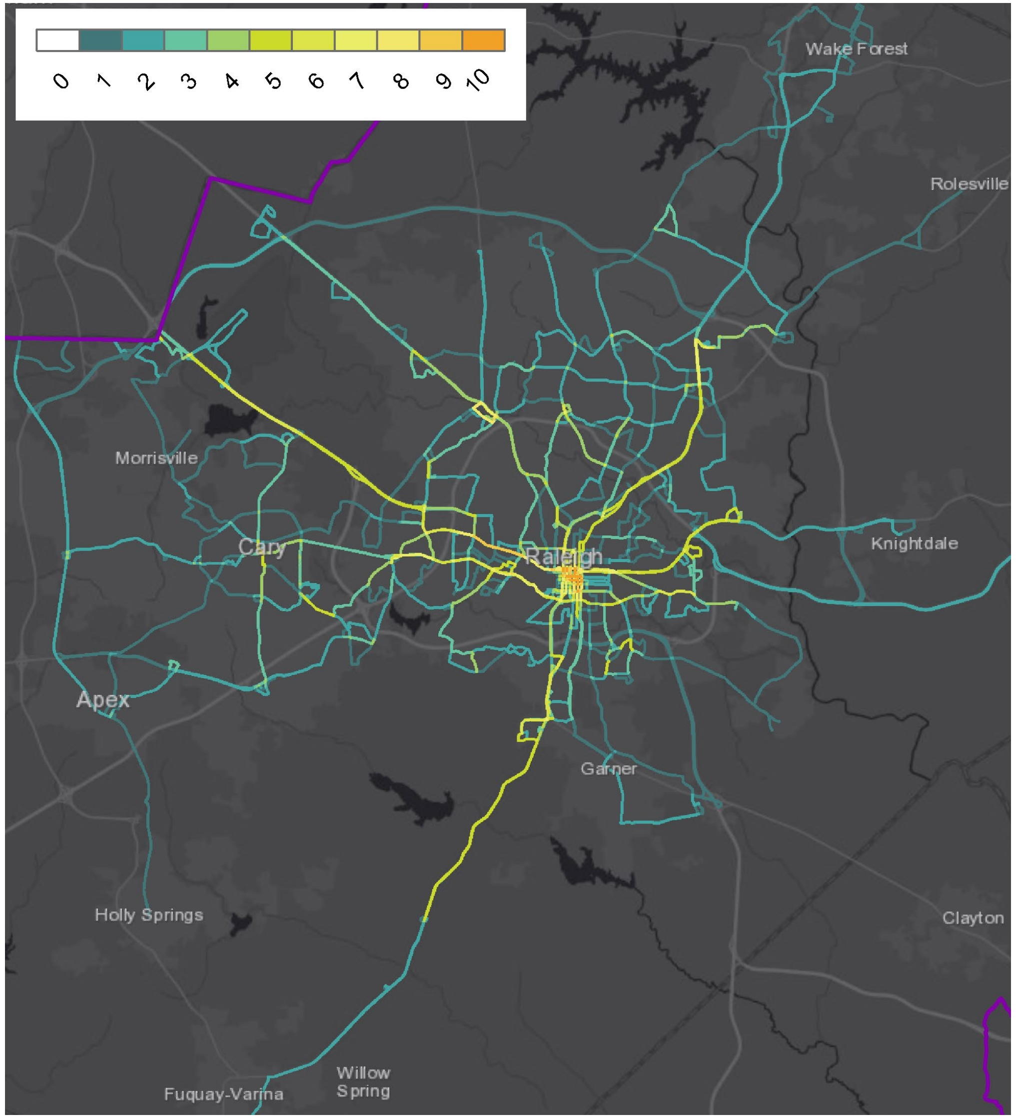
TRANSIT OPERATIONS – SERVICE FREQUENCY

Measure: Service Frequency (composite by year – see weights below)

- Analysis specs:
  - Floating zone: Circle with 200' radius
  - Overlay weights
    - 2018 (40%)
    - 2024 (30%)
    - 2027 (20%)
    - 2045 (10%)



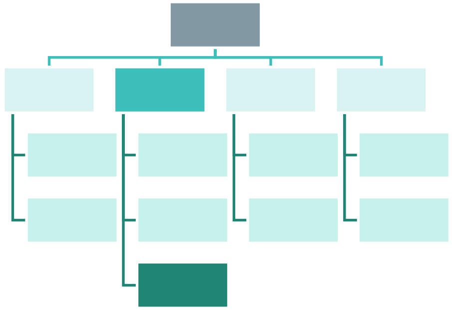
Buses per hour	Suitability Score
0	0
Up to 2	2
2 – 4	4
4 – 8	6
8 – 12	8
12+	10



TRANSIT OPERATIONS – BUS SPEED

Measure: Average Bus Speed

- Rationale:
  - RED Lanes can increase bus speeds, making service more convenient and competitive. Thus, they are appropriate on segments where bus speeds are typically slow.
- Sources:
  - TRM highway network bus speed forecasts (2045)
- Methods:
  - For a defined floating zone area, summarize the average bus speed.
  - Define thresholds to set “suitability tiers” based on estimated speeds.

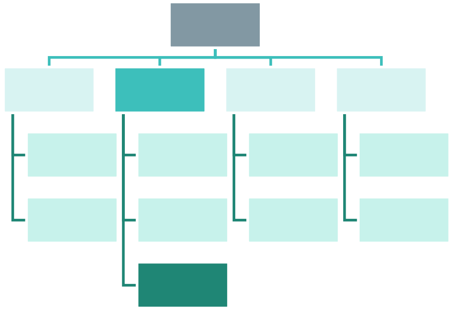


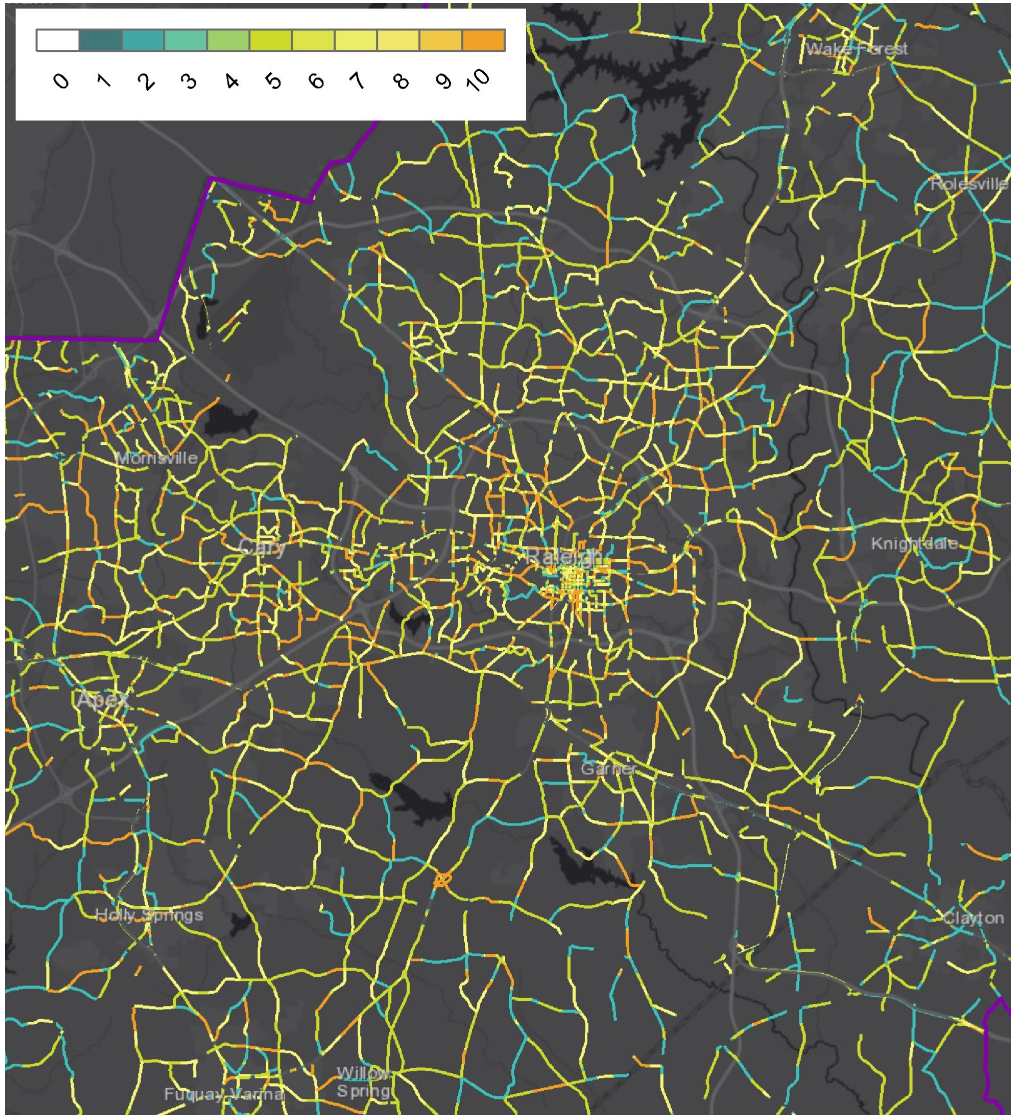
TRANSIT OPERATIONS – BUS SPEED

Measure: Average Bus Speed (2045)

- Analysis specs:
  - Floating zone: Circle with 200’ radius

Estimated bus speed	Suitability Score
0 – 8	10
8 – 12	8
12 – 16	5
16 – 20	2
20+	0

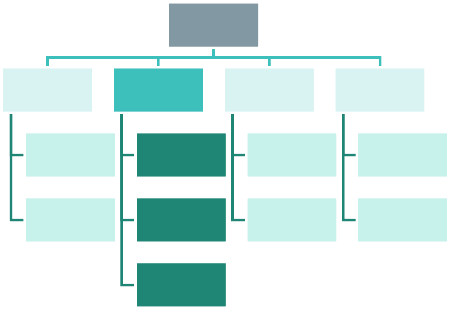


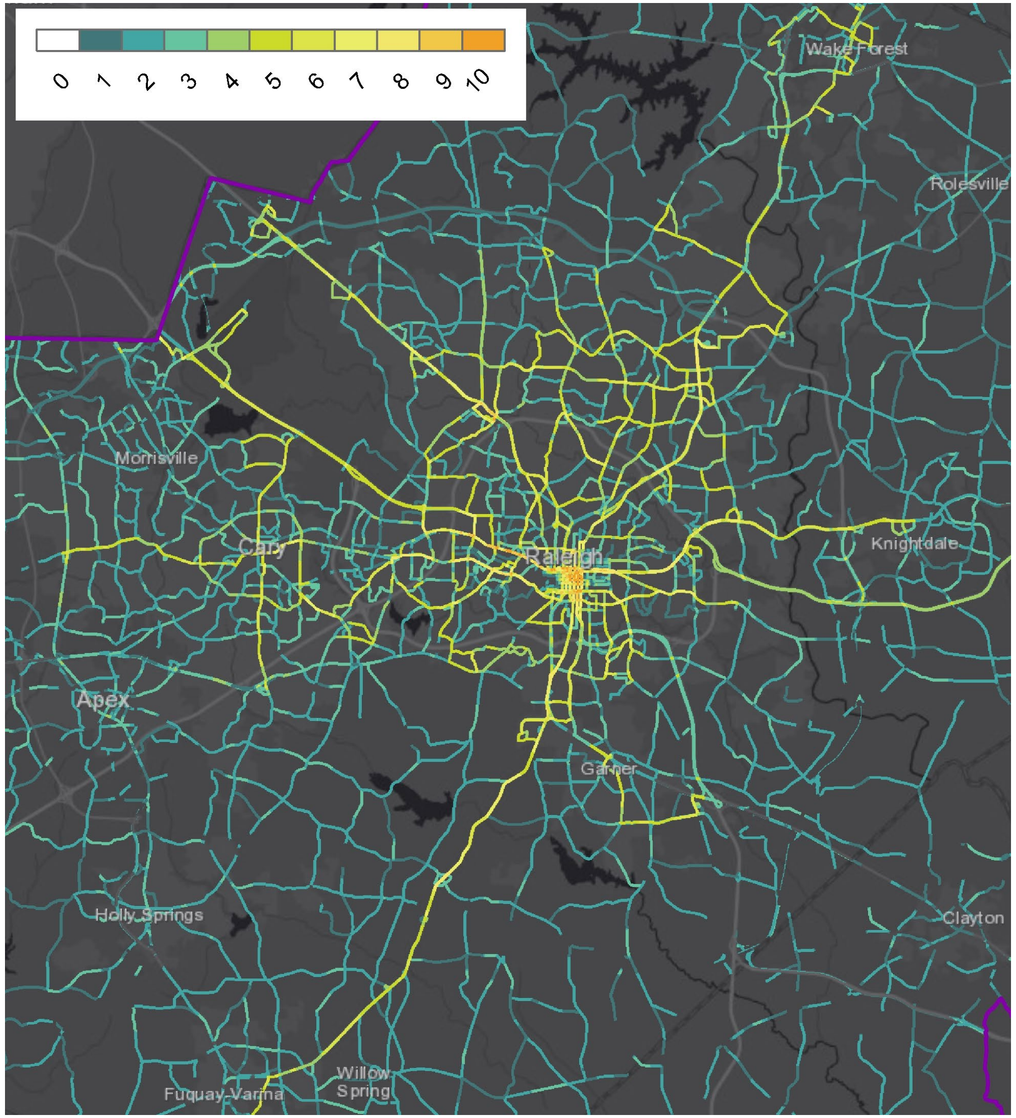


TRANSIT OPERATIONS – OVERLAY

Measure: Transit Operations Suitability

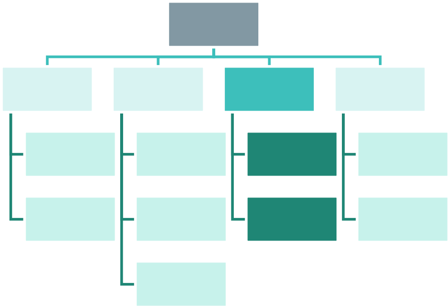
- Methods:
  - Overlay the on-time performance combo, service frequency overlay, and bus speed and take a weighted average.
    - On-Time Performance: 25%
    - Service Frequency: 50%
    - Bus Speed: 25%





HIGHWAY OPERATIONS – SCORING DIMENSIONS

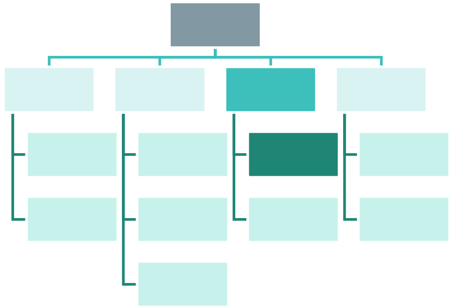
- Measures:
  - Vehicle Delay
  - V/C Ratio



HIGHWAY OPERATIONS – VEHICLE DELAY

Measure: Vehicle Delay

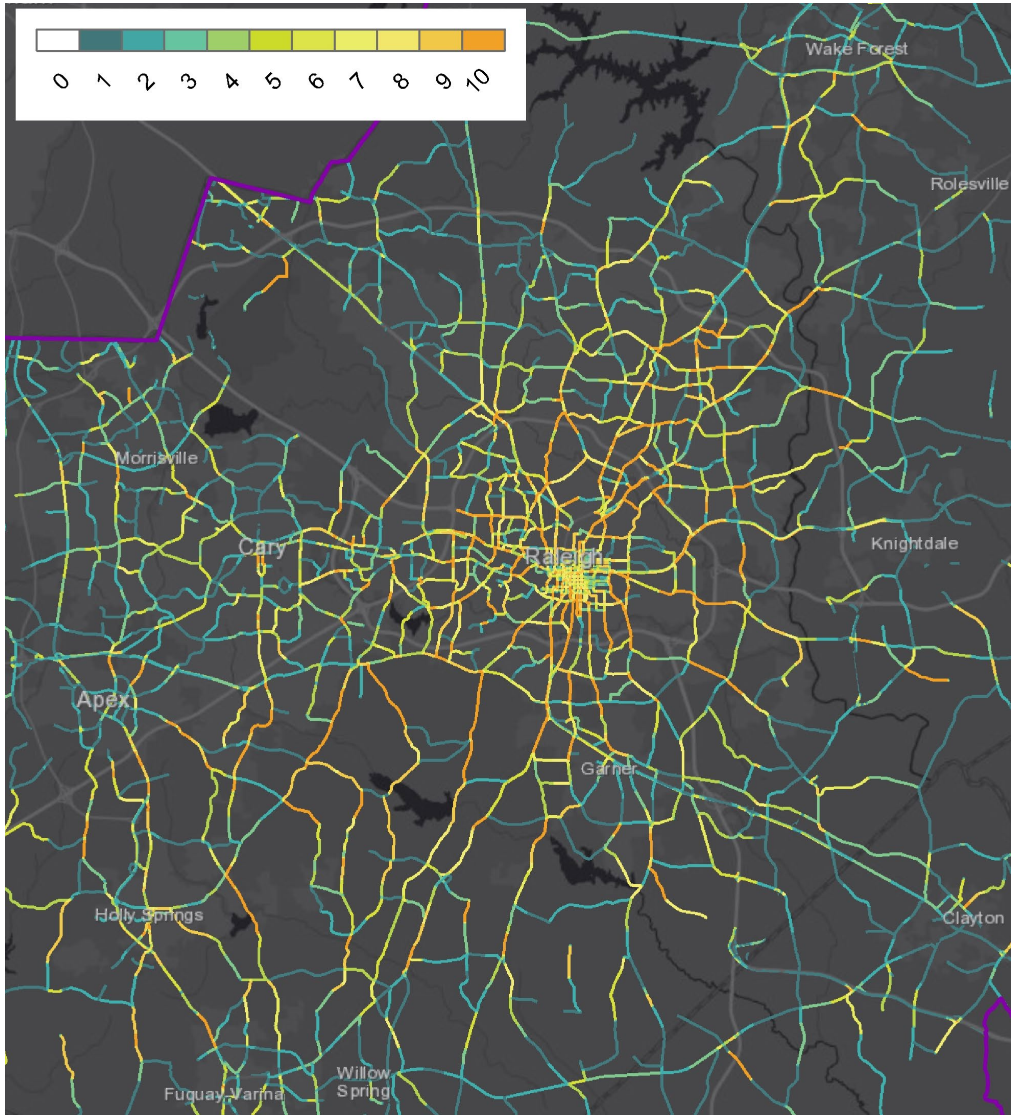
- Rationale:
  - RED Lanes provide more consistent travel conditions for transit vehicles in congested corridors and should be added to corridors where congestion impacts travel speeds.
- Sources:
  - TRM loaded highway network (2045)
- Methods:
  - For a defined floating zone area, summarize the minimum congested: free-flow speed ratio in the PM peak period.
  - Define thresholds to set "suitability tiers" based on congested: free-flow speed ratios.

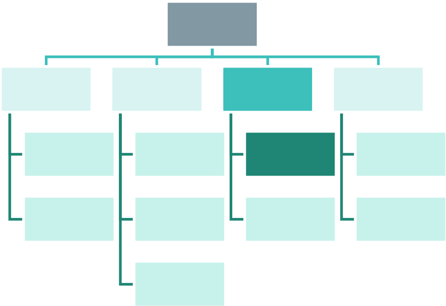


Measure: Vehicle delay (2045)

- Analysis specs:
  - Floating zone: Circle with 200’ radius

Congested: Free-flow speed ratio	Suitability Score
0.00 – 0.50	10
0.50 – 0.60	9
0.60 – 0.65	8
0.65 – 0.70	7
0.70 – 0.75	6
0.75 – 0.80	5
0.80 – 0.85	4
0.85 – 0.90	3
0.90 – 0.95	2
0.95 – 1.00	1

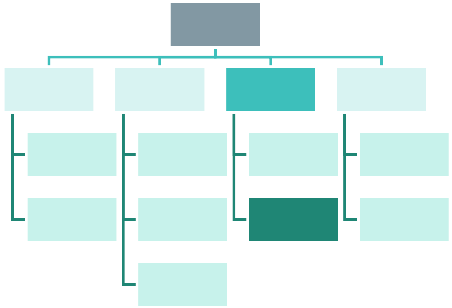




HIGHWAY OPERATIONS – V/C RATIO

Measure: V/C Ratio

- Rationale:
  - RED Lanes are most effective on segments where traffic congestion affects bus operations. However, extremely congested conditions call for general use capacity rather than transit priority lane investments.
- Sources:
  - TRM loaded highway network (2045)
- Methods:
  - For a defined floating zone area, summarize the maximum v/c ratio.
  - Define thresholds to set “suitability tiers” based on v/c ratios.

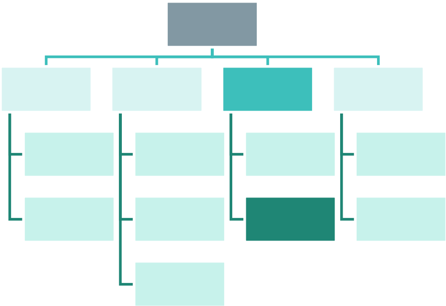


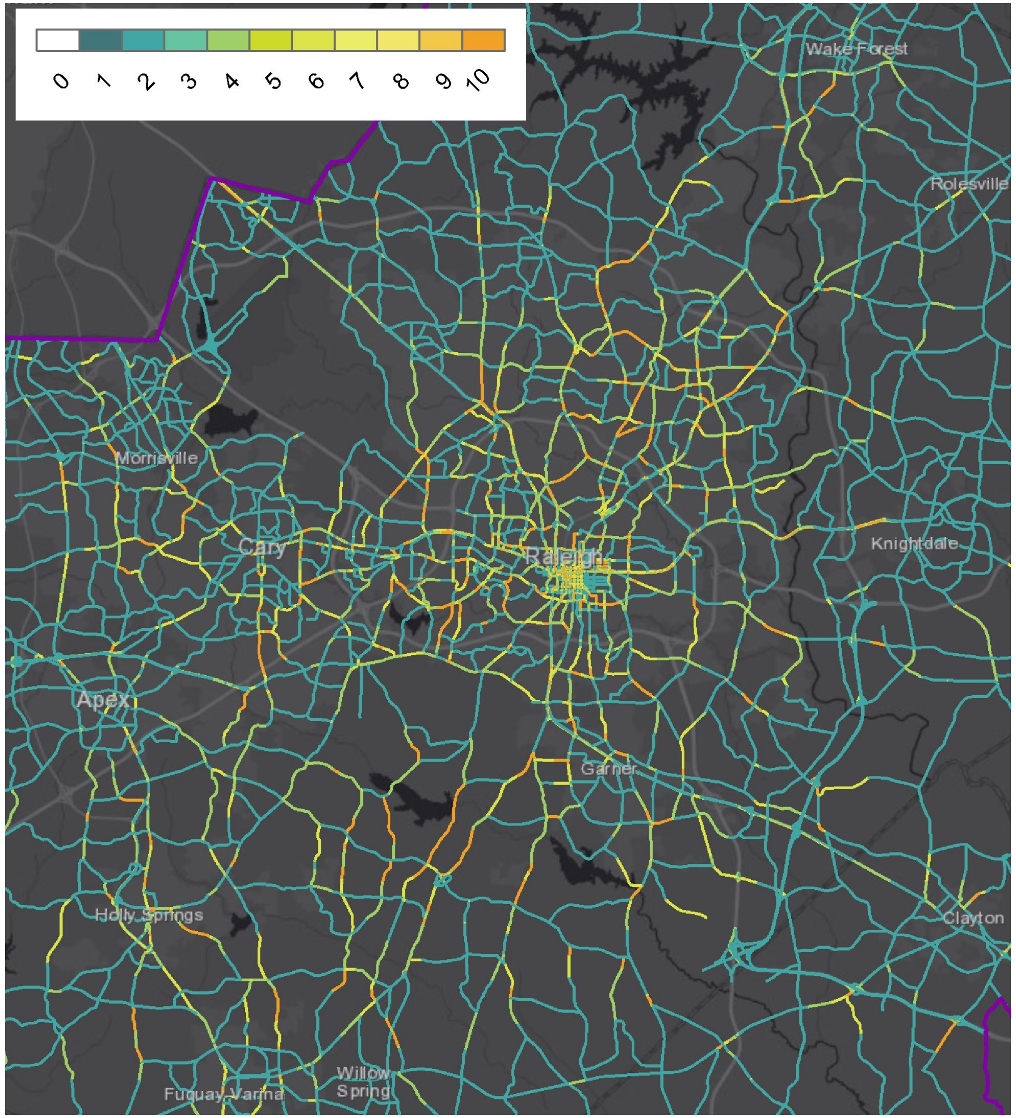
HIGHWAY OPERATIONS – V/C RATIO

Measure: V/C Ratio (2045)

- Analysis specs:
  - Floating zone: Circle with 200’ radius

V/C Ratio	Suitability Score
0 – 0.75	2
0.75 – 0.85	6
0.85 – 0.95	8
0.95 – 1.05	10
1.05 – 1.20	6
1.20 +	2

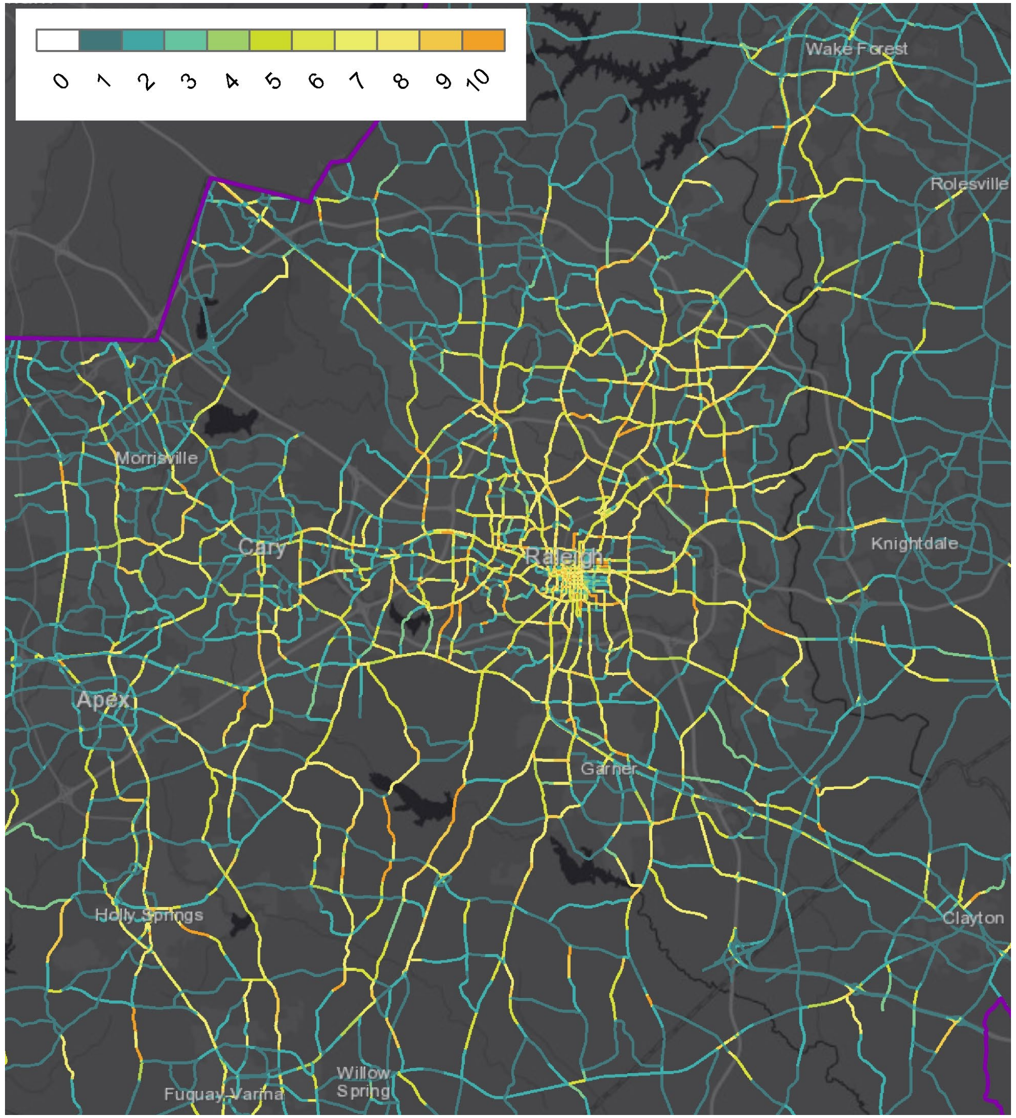


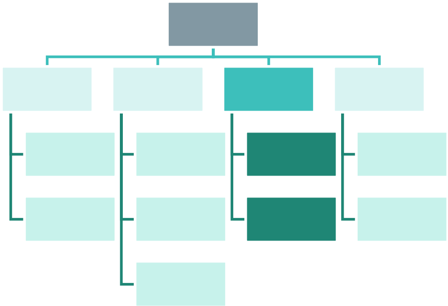


HIGHWAY OPERATIONS - OVERLAY

Measure: Highway Operations Suitability

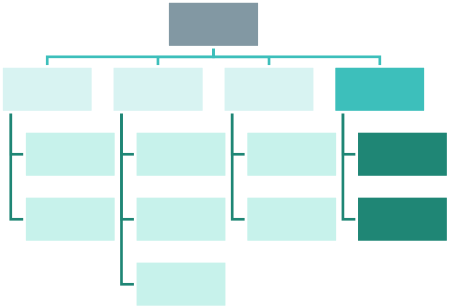
- Methods:
  - Overlay the vehicle delay and v/c ratio scores and take a weighted average
    - Vehicle delay: 50%
    - V/C ratio: 50%





CONTEXT AND DESIGN– SCORING DIMENSIONS

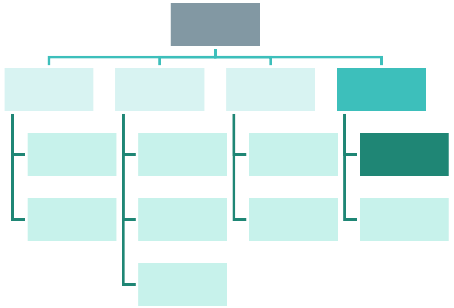
- Measures:
  - Activity unit density
  - Intersection density



CONTEXT AND DESIGN – ACTIVITY UNIT DENSITY

Measure: Activity Unit Density

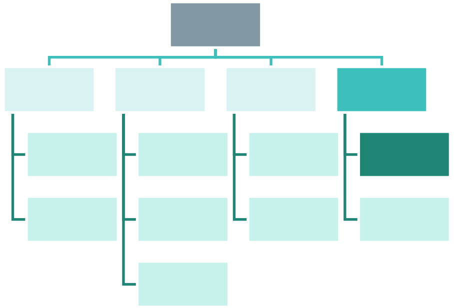
- Rationale:
    - Activity unit density (jobs + dwellings per acre) is a common component of "transit readiness" analyses. RED Lanes can be incorporated in complete streets designs and are generally appropriate in transit-supportive contexts.
- Sources:
    - TRM zonal data (2013)
- Methods:
    - Find the activity unit density for the zone(s) adjacent to each segment.
    - Define thresholds to set "suitability tiers" based on activity unit density.

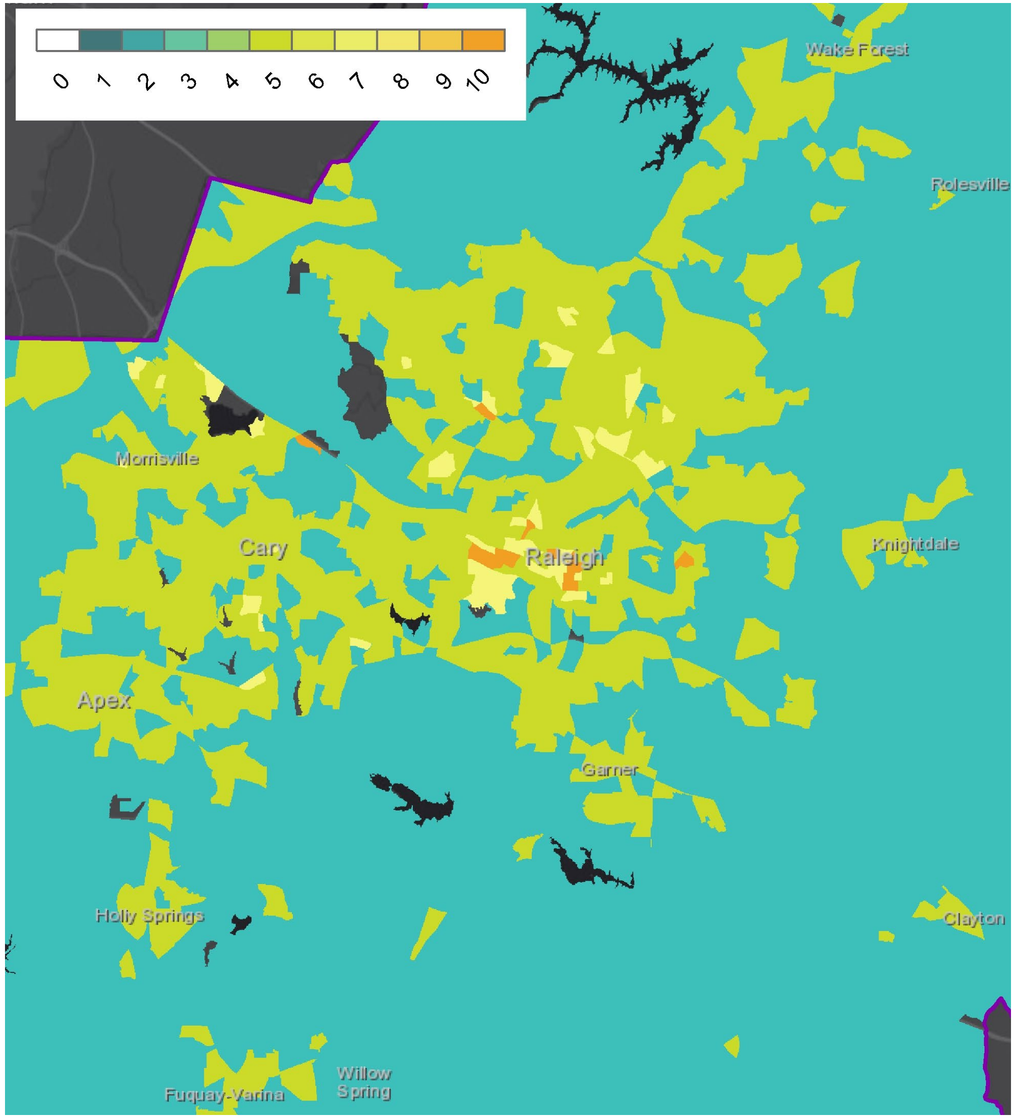


Measure: Activity Unit Density (2013)

- Analysis specs:
  - Adjacent zone activity density

Activity Unit Density	Suitability Score
0	0
0 – 5	2
5 – 21	5
21 – 49	8
49+	10

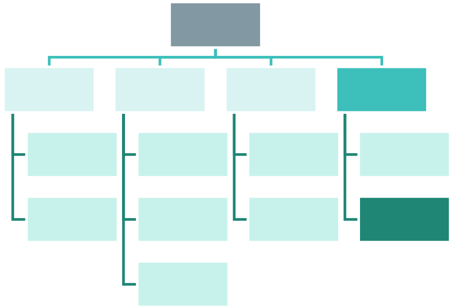




CONTEXT AND DESIGN – INTERSECTION DENSITY

Measure: Intersection Density

- Rationale:
  - Intersection density (intersections per square mile) is a common component of "transit readiness" analyses. RED Lanes can be incorporated in complete streets designs and are generally appropriate in transit-supportive contexts.
- Sources:
  - EPA Smart Location Database (variable D3b, circa 2010)
- Methods:
  - Find the intersection density for the zone(s) adjacent to each segment.
  - Define thresholds to set "suitability tiers" based on intersection density.

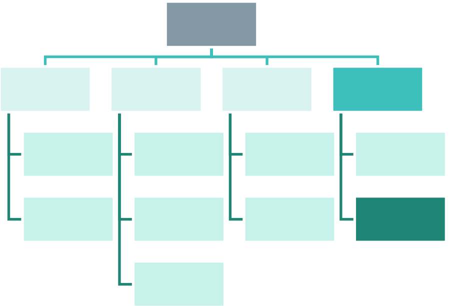


CONTEXT AND DESIGN – INTERSECTION DENSITY

Measure:
Intersection Density (c. 2010)

- Analysis specs:
  - Adjacent zone intersection density

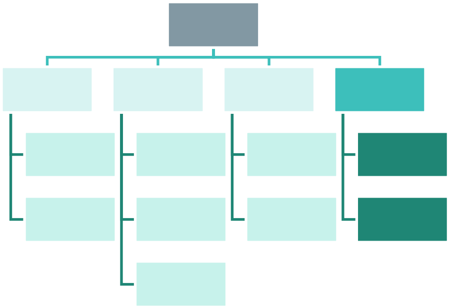
Intersection Density	Suitability Score
0	0
0 – 70	2
70 – 100	5
100 – 226	8
226 +	10

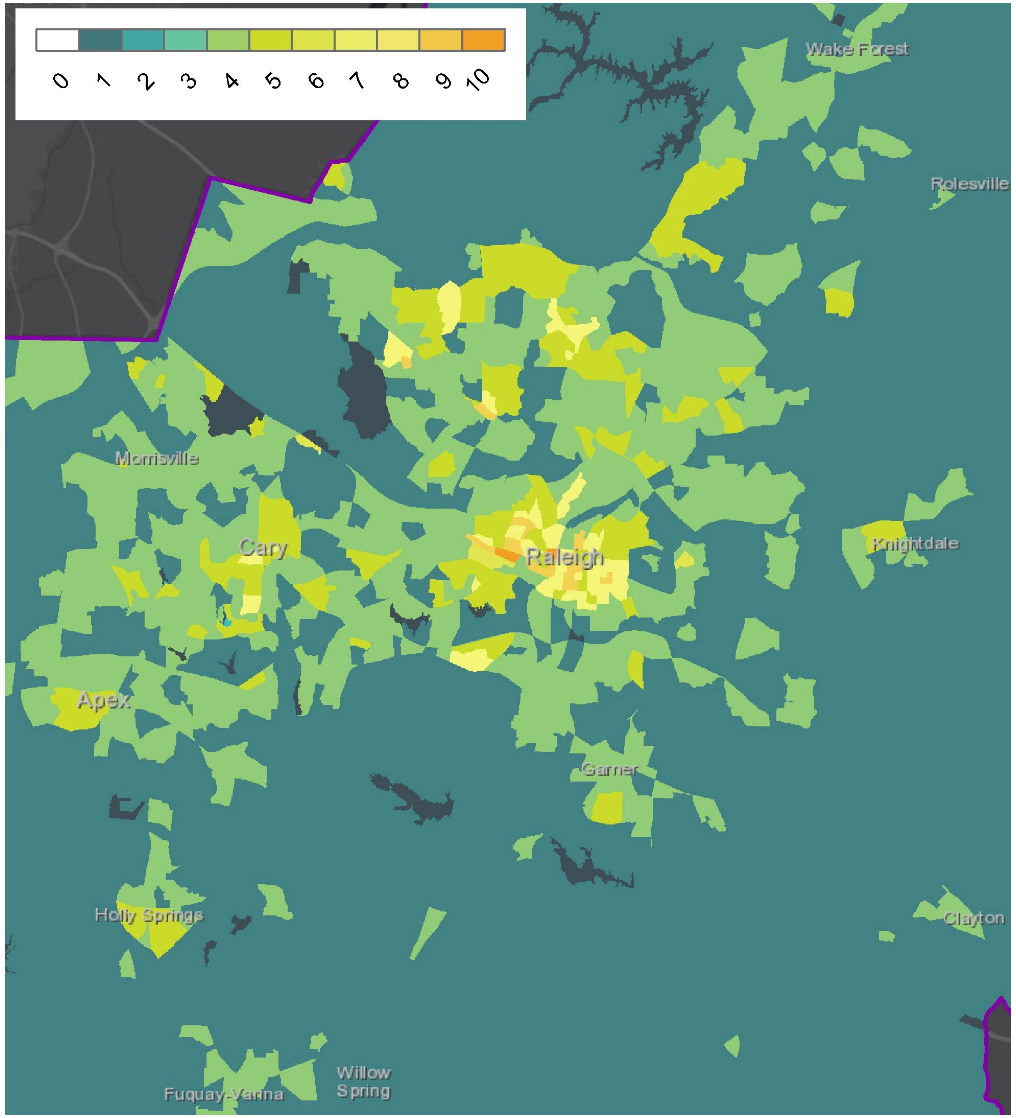


CONTEXT AND DESIGN– SCORING DIMENSIONS

Measure: Context and Design Suitability

- Methods:
  - Overlay the activity density and intersection density scores and take a weighted average
    - Activity unit density: 50%
    - Intersection density: 50%

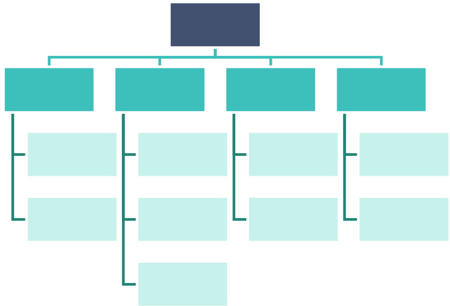


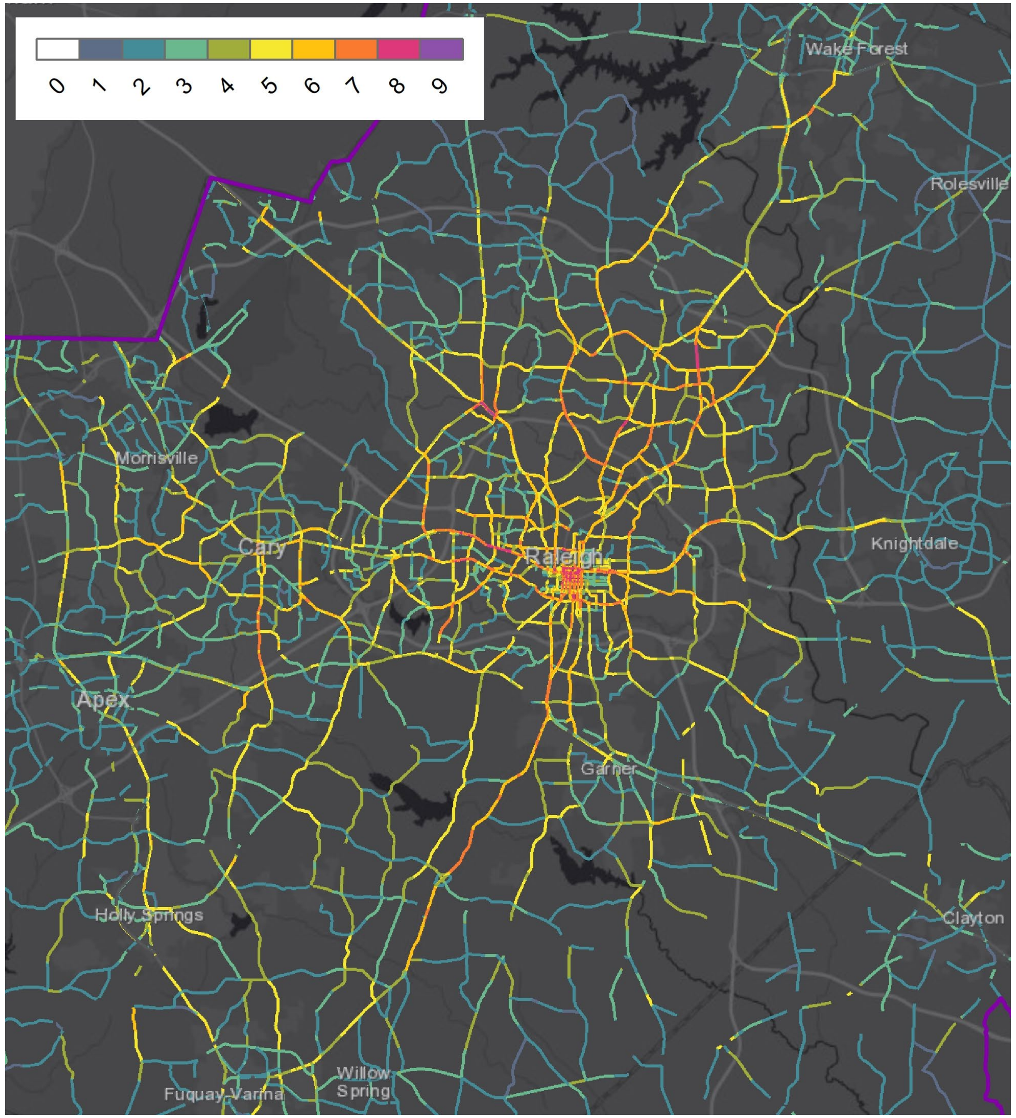


RED LANES SUITABILITY OVERLAY

- Dimensions (weights based on feedback from RED Lanes Core Technical Team and CAMPO Technical Coordinating Committee):
  - Travel Demand (30%)
  - Transit Operations (25%)
  - Highway Operations (30%)
  - Context and Design (15%)

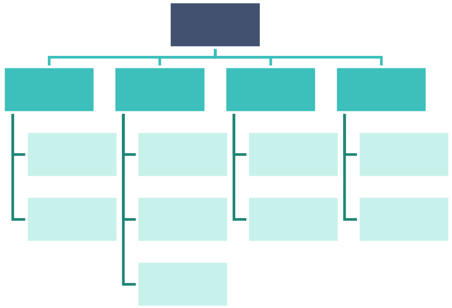
Since highway datasets were included in the suitability scoring, many facilities with no existing or planned transit have a suitability score. We can mask these out by only including segments with existing or planned transit service (see next slide).

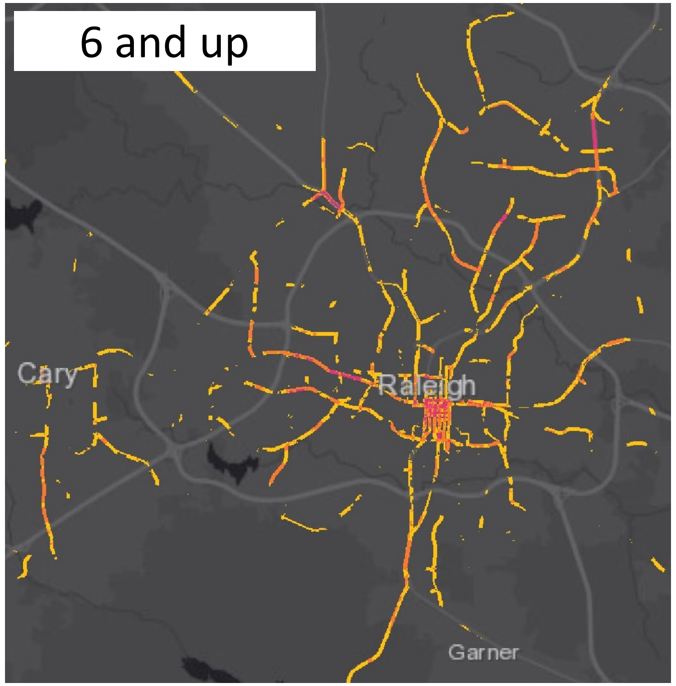


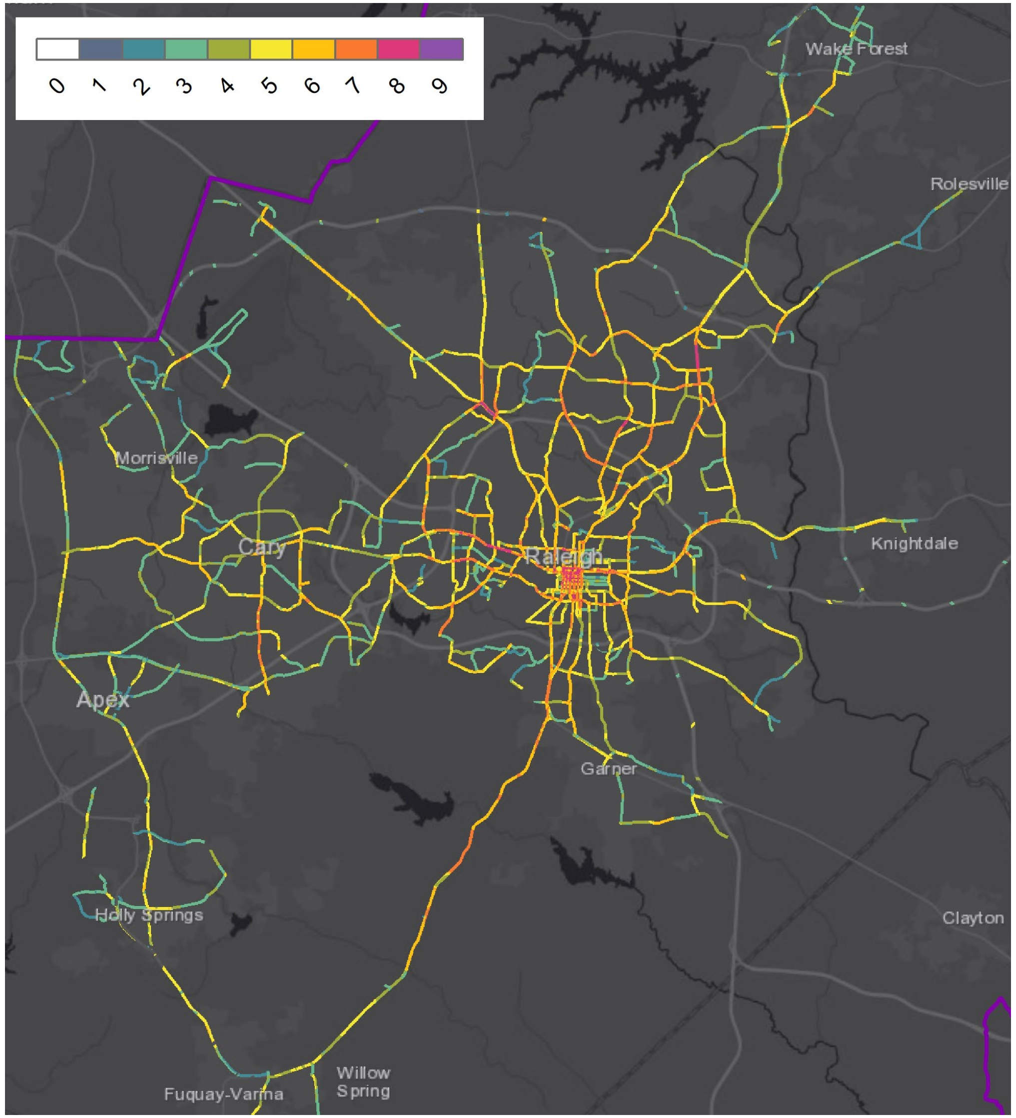


RED LANES SUITABILITY OVERLAY

- Dimensions:
  - Travel Demand (30%)
  - Transit Operations (25%)
  - Highway Operations (30%)
  - Context and Design (15%)



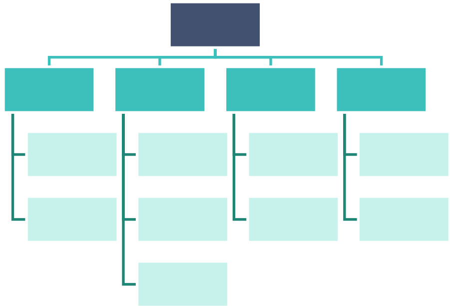


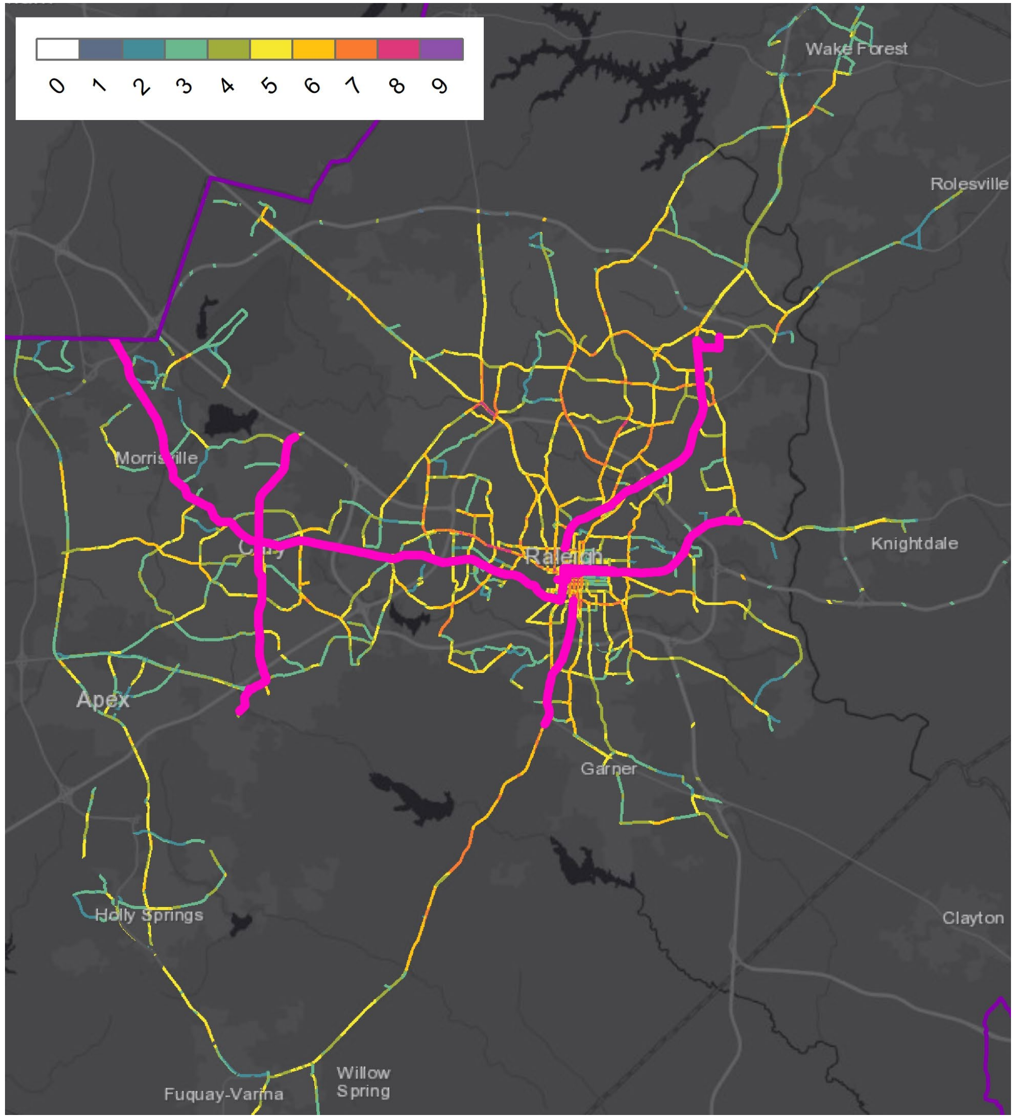


RED LANES SUITABILITY OVERLAY

- Dimensions:
  - Travel Demand (30%)
  - Transit Operations (25%)
  - Highway Operations (30%)
  - Context and Design (15%)

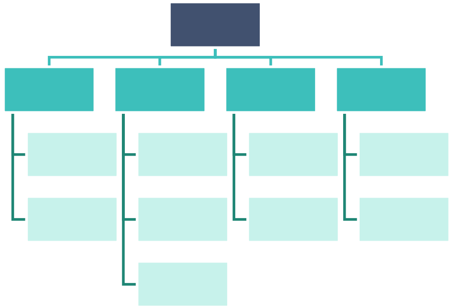
Some segments are already being studied for potential fixed-guideway transit improvements. RED Lanes scores are retained for these segments, but it also helpful to mask these segments out for some maps to show highly-suitable sections of other corridors.

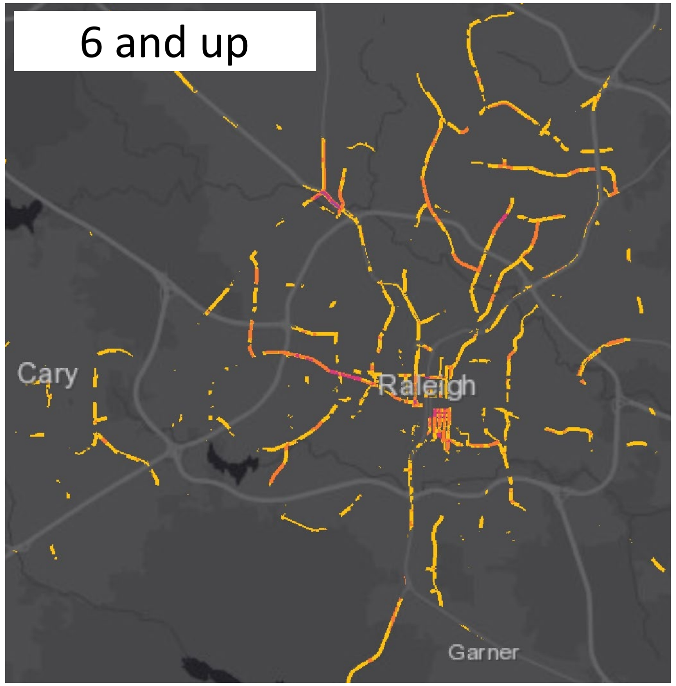


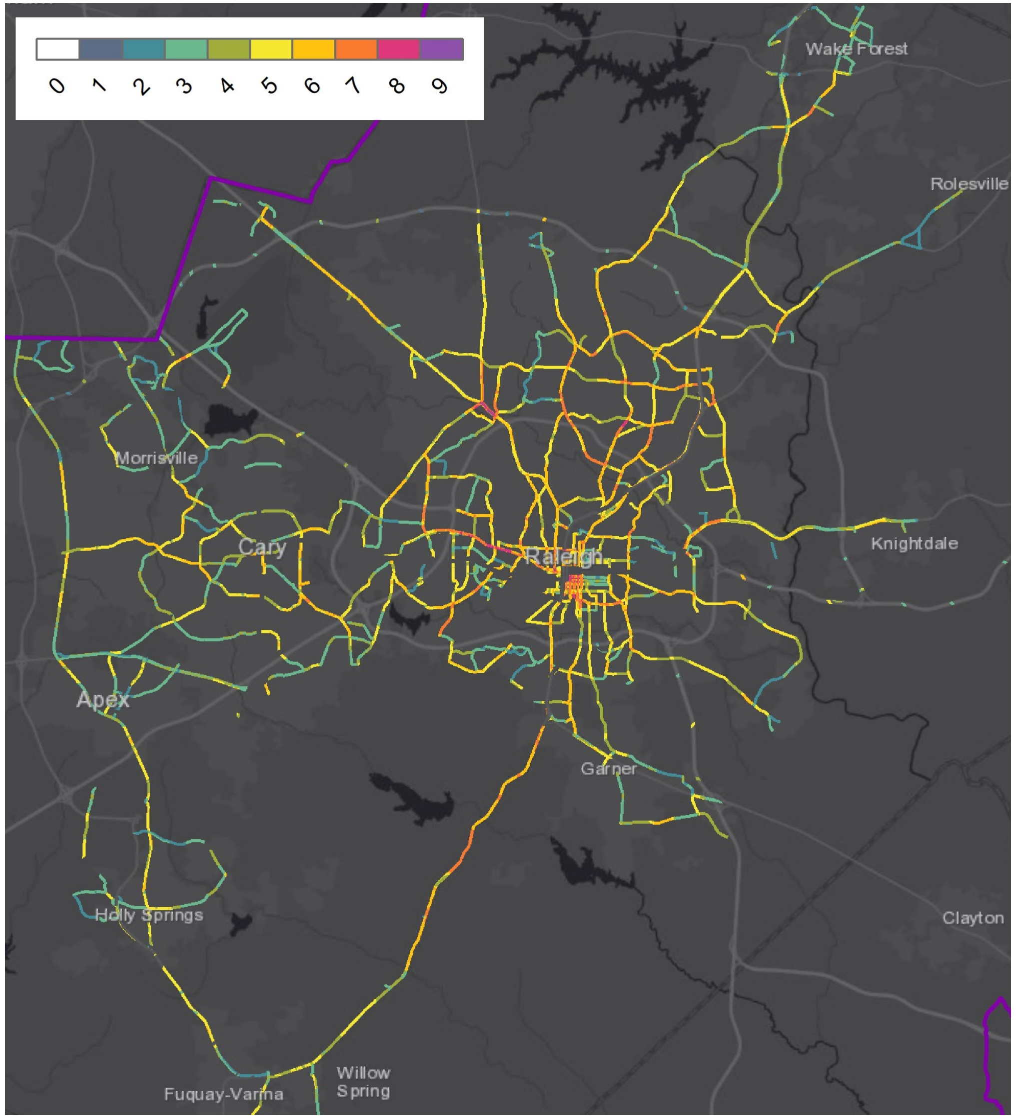


RED LANES SUITABILITY OVERLAY

- Dimensions:
  - Travel Demand (30%)
  - Transit Operations (25%)
  - Highway Operations (30%)
  - Context and Design (15%)



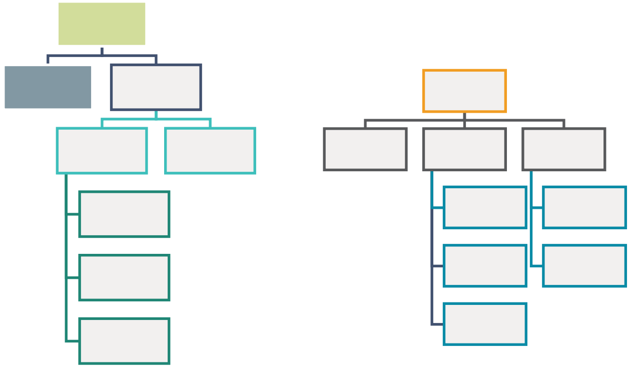




3 WALKTHROUGH OF ENRICHMENT ELEMENTS

WALKTHROUGH OF SUITABILITY ELEMENTS

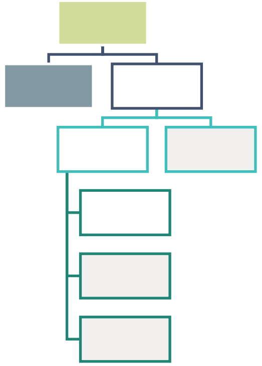
- The following slides provide details of how RED Lanes Enrichment data were developed, including data sources, analysis parameters, scoring rubrics and maps.
- The diagram in the lower left corner indicates which components of the scoring process are depicted in each slide.



FEASIBILITY – RIGHT OF WAY IMPACTS

Measure: Number of buildings impacted per mile with the addition of 11’ RED Lanes in each direction.

- Rationale:
  - RED Lanes utilize right-of-way. In constrained corridors where buildings are near the street, adding RED Lanes in each direction may impact existing buildings, presenting implementation challenges.
- Sources:
  - NC Route Characteristics shape file
  - Microsoft building footprints
- Methods:
  - See ECR report for estimation of buildings-impacted-per-mile due to adding RED Lanes.
  - For a defined floating zone area, take the average number of buildings impacted per mile.
  - Define thresholds to set “feasibility tiers” based on ROW impacts



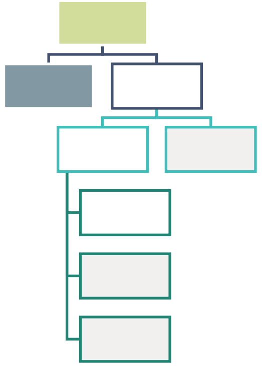
FEASIBILITY – RIGHT OF WAY IMPACTS

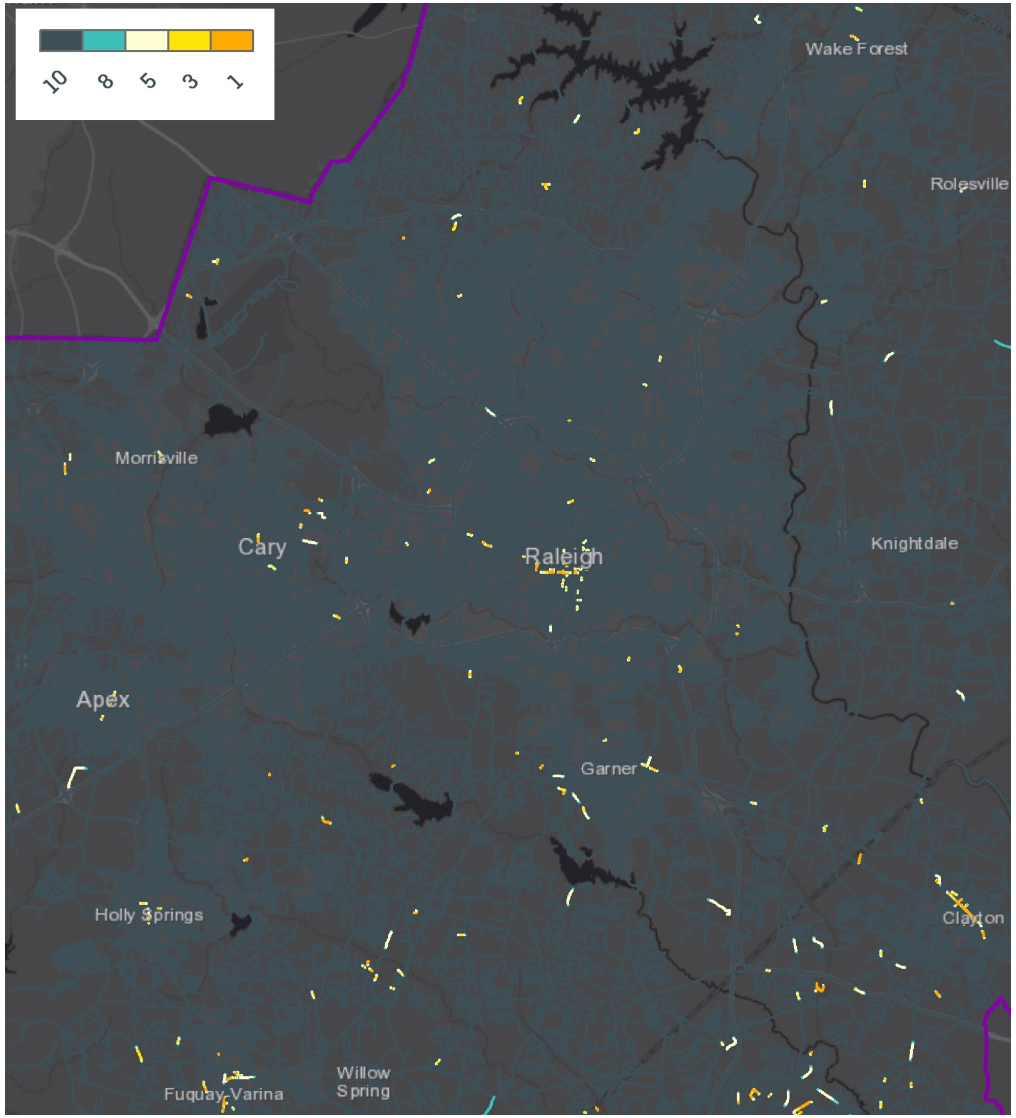
Measure: Potential ROW Impacts (c. 2018)

- Analysis specs:
  - Floating zone: Circle with 200’ radius

*Includes all streets in NC route characteristics layer. Highlights **low-feasibility** segments.*

Buildings Impacted per Mile Range	Feasibility Score
0	10
0 – 1	8
1 – 5	5
5 – 9	3
9 +	1

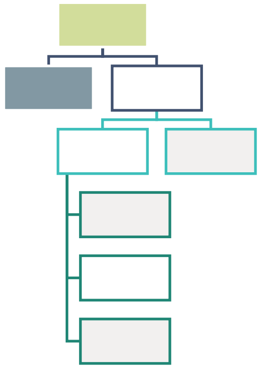




FEASIBILITY – NUMBER OF LANES

Measure: Number of travel lanes in each direction on the existing network

- Rationale:
  - It is not always necessary to add lanes to create RED Lanes. In some cases, taking an existing lane may be feasible. This assessment focuses on existing lane counts to provide a coarse sense of where this approach may be possible.
- Sources:
  - TRM highway network (2013)
- Methods:
  - For a defined floating zone area, take the maximum number of lanes in each travel direction.
  - Define thresholds to set “feasibility tiers” based on number of lanes.



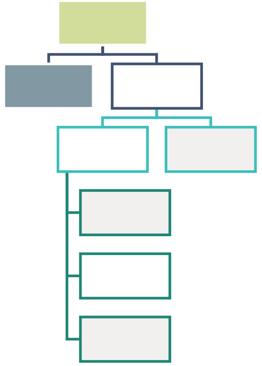
FEASIBILITY – NUMBER OF LANES

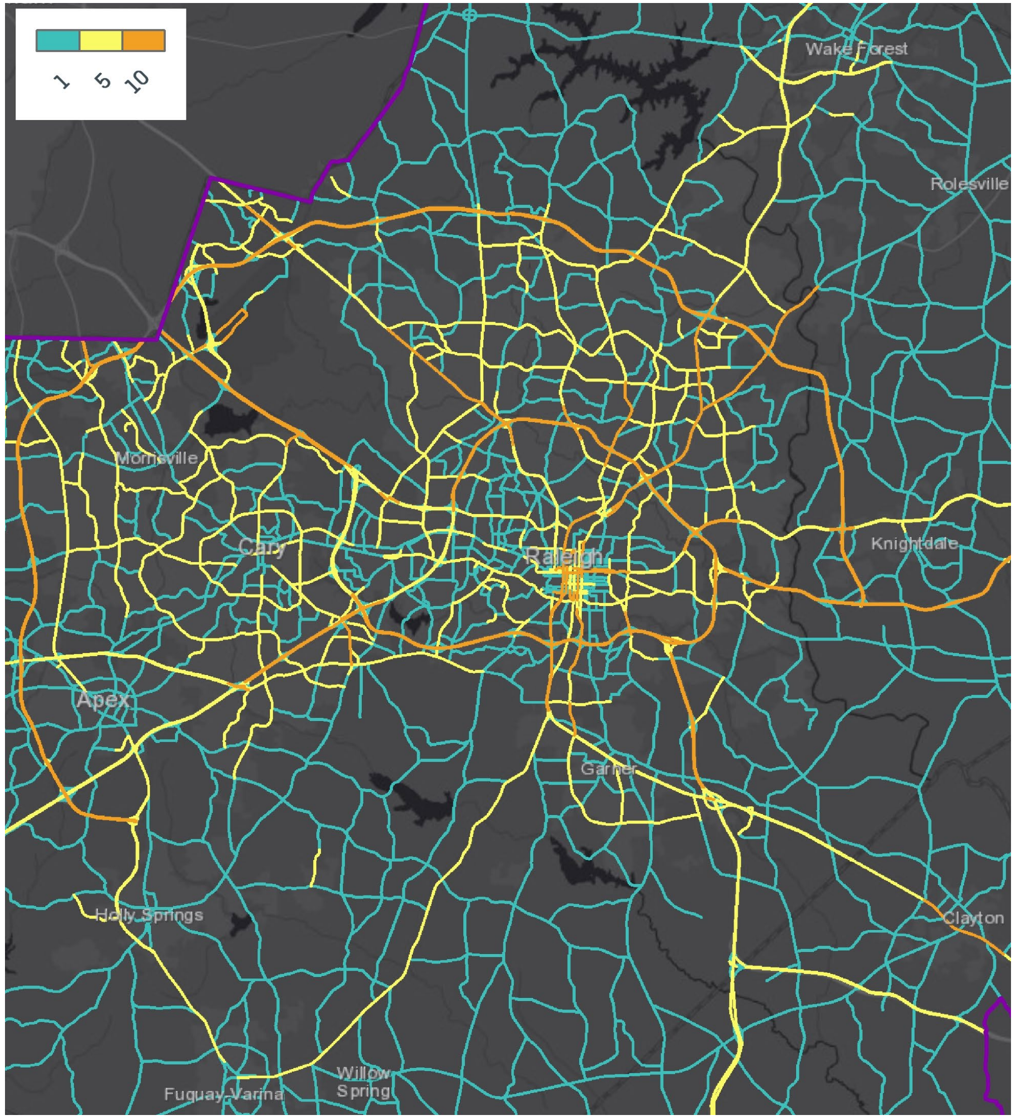
Measure: Number of Lanes (2013)

- Analysis specs:
  - Floating zone: Circle with 200' radius

*Includes all streets in TRM. Highlights **high-feasibility** segments.*

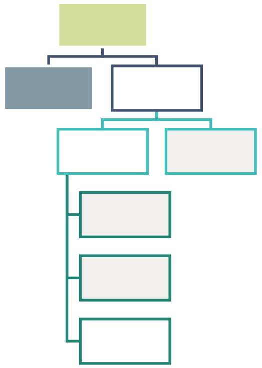
Number of Lanes Range	Feasibility Score
1/direction	1
2/direction	5
3+/direction	10





Measure: Number of travel lanes added in each direction

- Rationale:
  - Whether a facility has constraints or limited number of existing lanes, RED Lanes may be feasible on segments that are already expected to be widened per adopted plans.
- Sources:
  - TRM highway network (2045)
- Methods:
  - For a defined floating zone area, take the maximum number of new lanes added.
  - Define thresholds to set “feasibility tiers” based on number of added lanes.



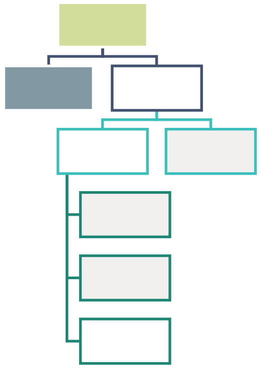
FEASIBILITY – PLANNED WIDENINGS

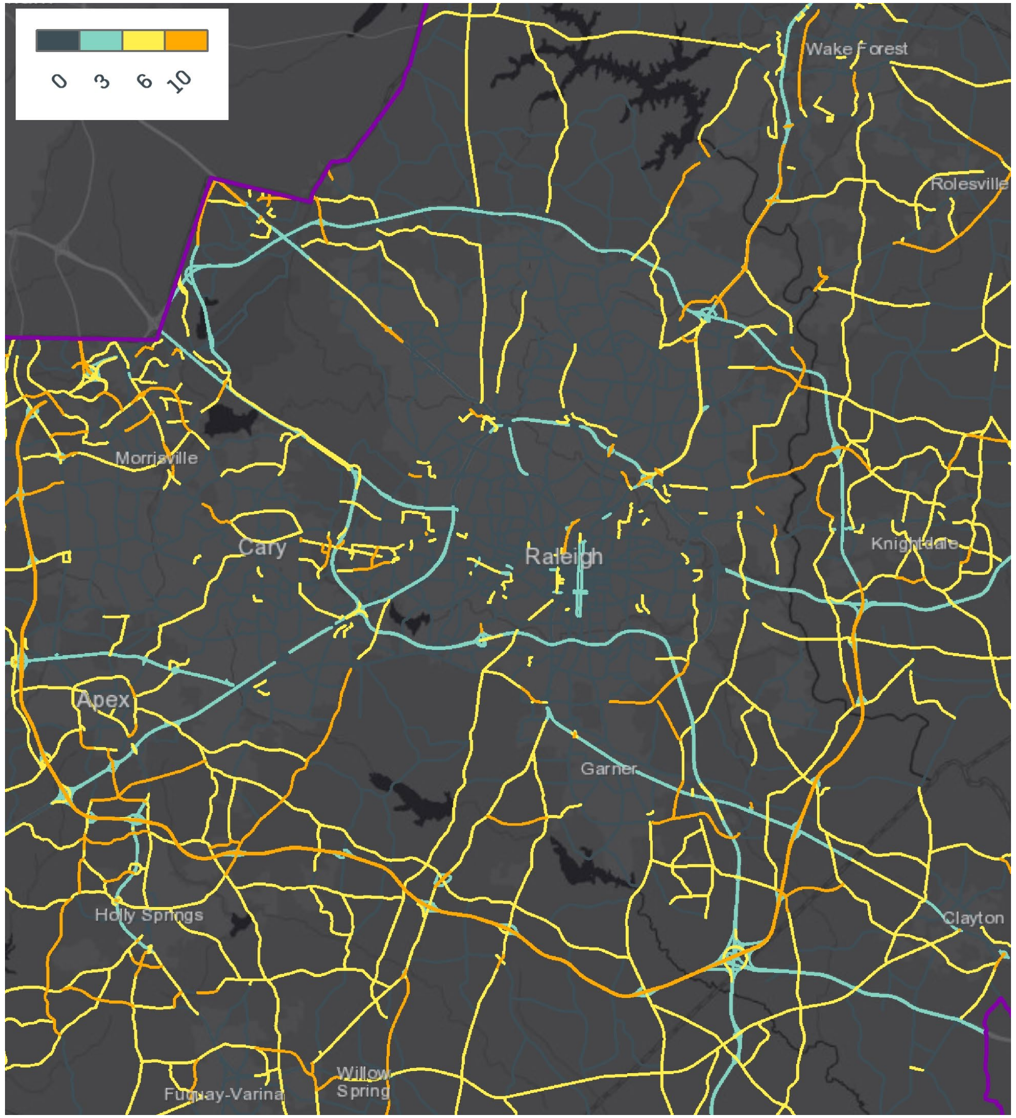
Measure: Planned Widenings (by 2045)

- Analysis specs:
  - Floating zone: Circle with 200' radius

*Includes all streets in TRM. Highlights **high-feasibility** segments.*

Number of Lanes Added Range	Feasibility Score
0	0
1	3
2	6
3+	10

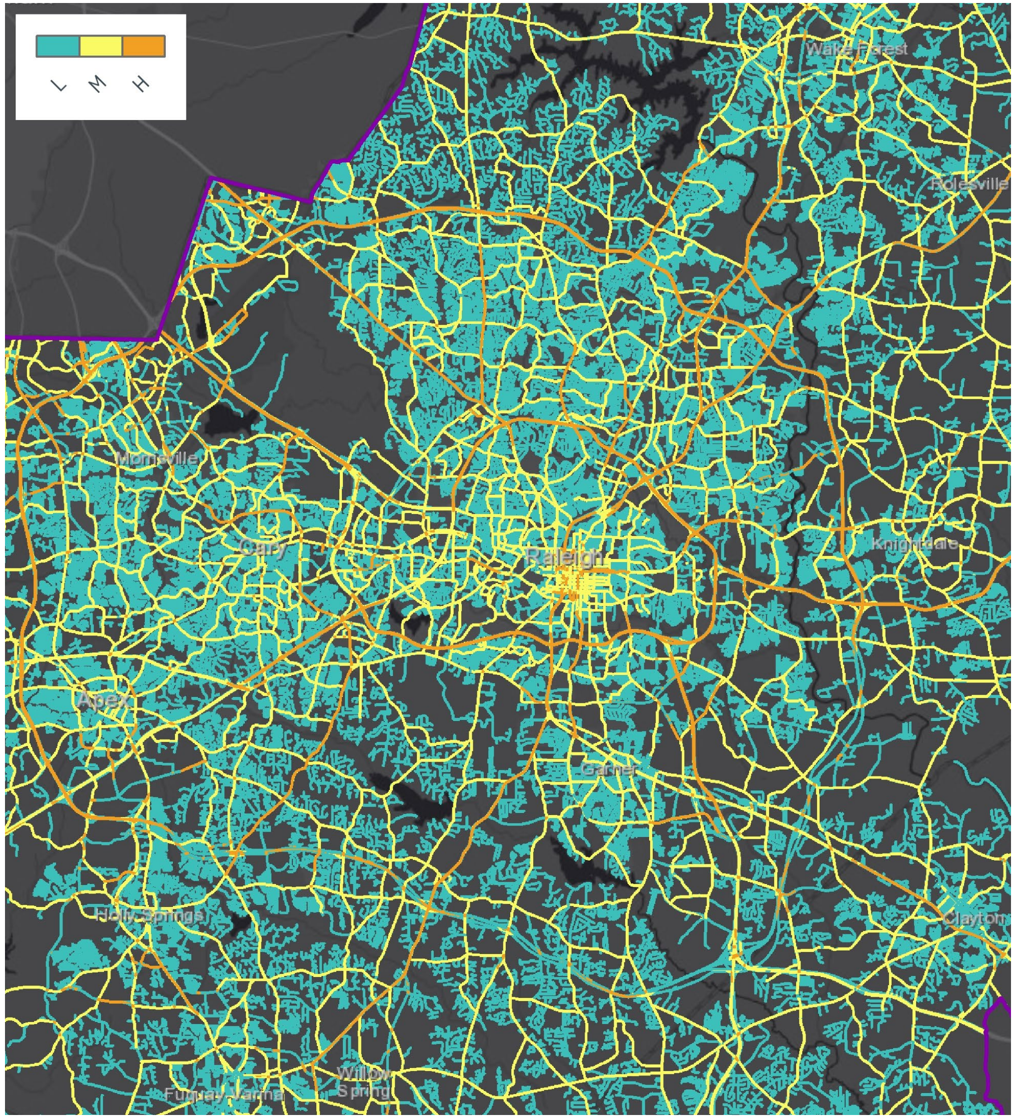




FEASIBILITY OVERLAY

Measure: Feasibility Score Overlay

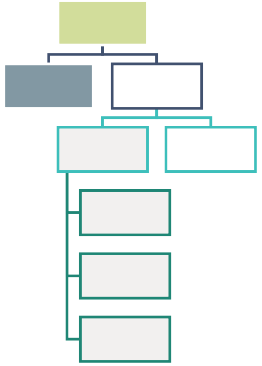
- Methods:
  - Overlay the ROW impacts estimates, number of existing lanes, and planned widenings and take a weighted average
    - ROW impacts (33%)
    - Number of lanes (33%)
    - Planned widenings (34%)
  - Reclassify overlay results:
    - 3 or less = low feasibility
    - 4 – 6 = medium feasibility
    - 7+ = high feasibility



COMMUNITIES OF CONCERN

Measure: Number overlapping communities of concern

- Rationale:
  - RED Lanes that could provide mobility benefits to disadvantaged populations should be differentiated from those that do not. Higher numbers of overlapping groups in the CAMPO Communities of Concern dataset indicate greater prospective benefits to different population segments.
- Sources:
  - CAMPO Communities of Concern polygons
- Methods:
  - Find the number of overlapping communities of concern flagged in the block group(s) adjacent to each segment.
  - Define thresholds to set “equity tiers” based on number of overlapping communities of concern.

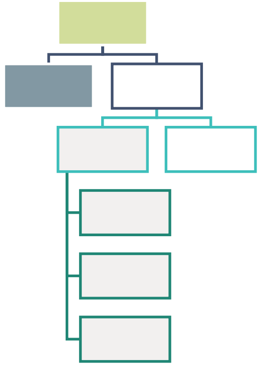


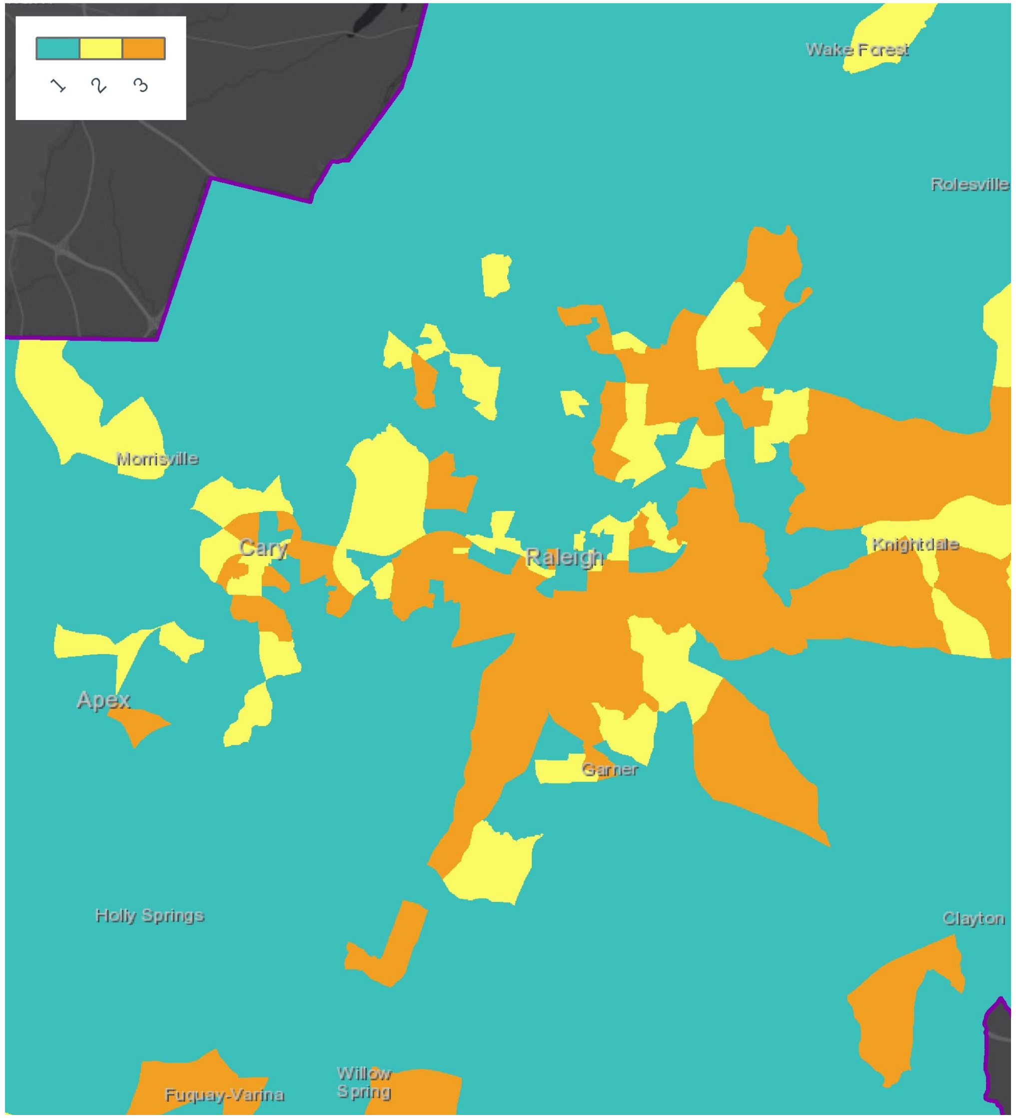
COMMUNITIES OF CONCERN

Measure: Overlapping Communities of Concern (2016)

- Analysis specs:
  - Adjacent block group count of overlapping Communities of Concern

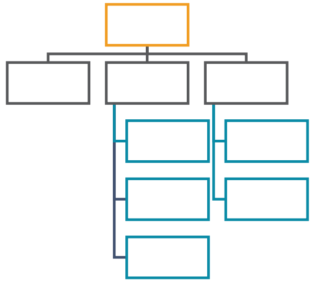
Number of overlapping CofC's Range	Equity Score
0 – 1	1
1 – 2	2
2+	3





IMPLEMENTATION GUIDANCE

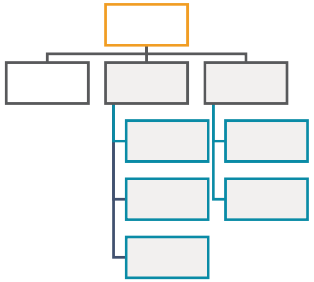
- Measures:
  - **Non-motorized propensity** – uses walk access to jobs as a proxy for the likelihood of non-motorized users in/near a potential RED Lane.
  - **TSP suitability** – a coarse assessment of whether transit-signal priority might be an appropriate operational improvement accompanying RED Lanes in a segment.
  - **Full-time suitability** – evaluates whether a segment should be considered for full-time RED Lanes of if part-time lanes are more appropriate.
    - Peaking of transit ridership (2045)
    - Peaking of traffic volume (2045)



NON-MOTORIZED PROPENSITY

Measure: Walk access to jobs from adjacent blocks

- Rationale:
  - Non-motorized (walking and biking) travel is often correlated with walk access to nearby employment. In RED Lane candidate segments adjacent to blocks with high accessibility, facility design should account for non-motorized users.
- Sources:
  - University of Minnesota Accessibility Observatory Walk Access Scores (2014)
- Methods:
  - Record the number of jobs reachable by walking in census block(s) adjacent to each segment.
  - Define thresholds to set “Non-motorized propensity tiers” based on walk access values.

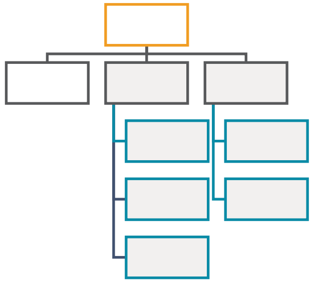


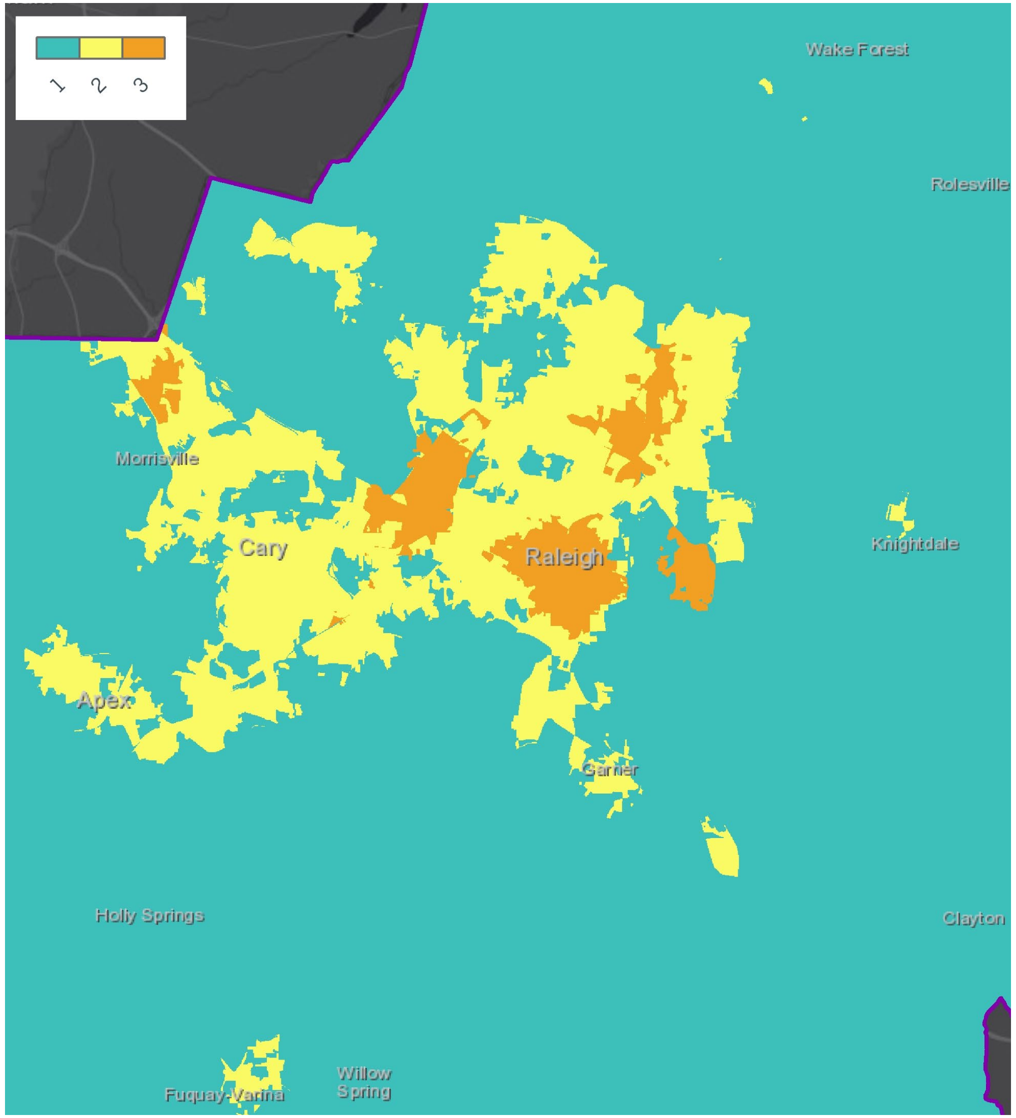
NON-MOTORIZED PROPENSITY

Measure: Walk access to jobs (2014)

- Analysis specs:
    - Adjacent block walk access to jobs score

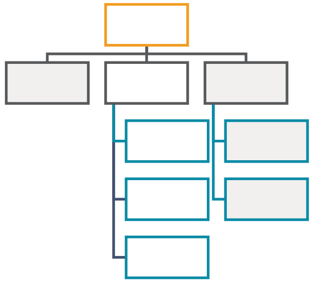
Walk Access Score Range	Non-motorized Propensity Score
-1 – 2,500	1
2,500 – 10,000	2
10,000+	3





TSP SUITABILITY

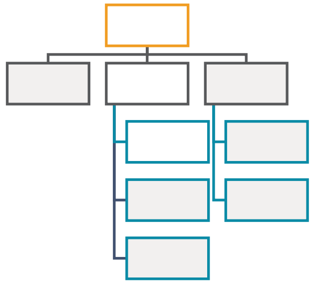
- Measures:
  - Vehicle Delay
  - V/C Ratio
  - Transit On-Time Performance



TSP SUITABILITY – VEHICLE DELAY

Measure: Vehicle Delay

- Rationale:
    - TSP is appropriate in corridors with moderate delay. In segments with minimal delay, transit vehicles general experience limited delay due to signals, while in those with significant delays, transit vehicles often cannot reach the intersection to take advantage of signal priority.
- Sources:
    - TRM loaded highway network (2045)
- Methods:
    - For a defined floating zone area, summarize the minimum congested: free-flow speed ratio in the PM peak period.
    - Define thresholds to set “TSP suitability tiers” based on congested: free-flow speed ratios.

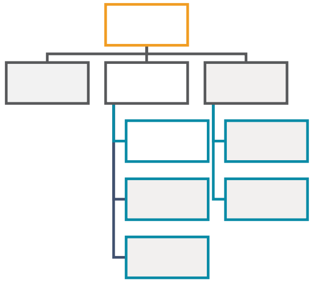


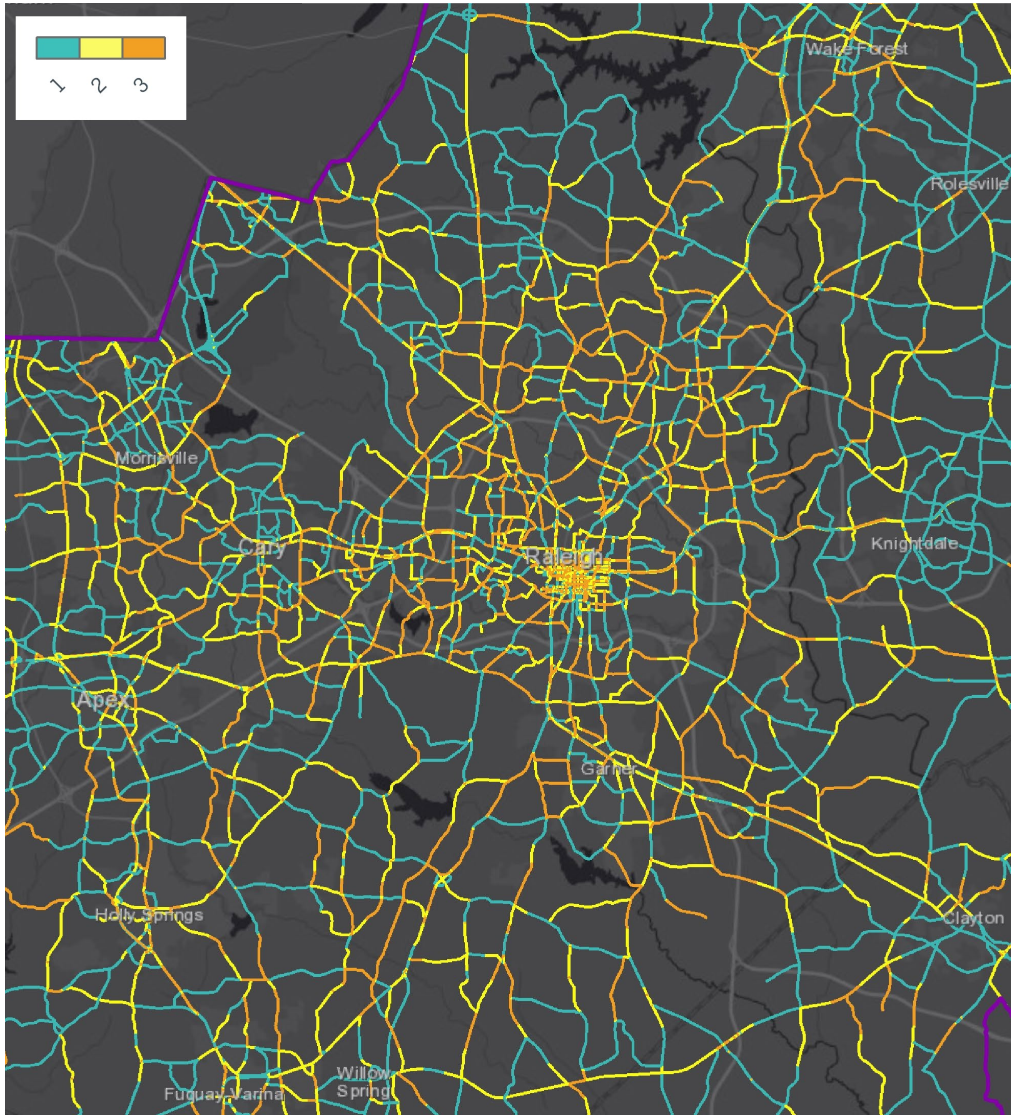
TSP SUITABILITY – VEHICLE DELAY

Measure: Vehicle delay (2045)

- Analysis specs:
  - Floating zone: Circle with 200’ radius

Congested: Free-flow speed ratio	TSP Suitability Score
0.00 – 0.50	1
0.50 – 0.60	2
0.60 – 0.80	3
0.80 – 0.90	2
0.9 – 1	1

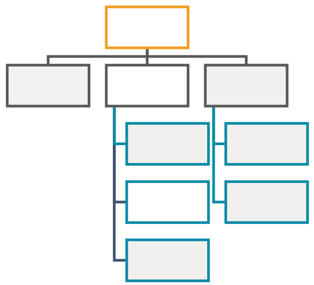




TSP SUITABILITY – V/C RATIO

Measure: V/C Ratio

- Rationale:
  - Similar to delay, TSP is best suited in corridors with moderate V/C ratios.
- Sources:
  - TRM loaded highway network (2045)
- Methods:
  - For a defined floating zone area, summarize the maximum v/c ratio.
  - Define thresholds to set “TSP suitability tiers” based on v/c ratios.

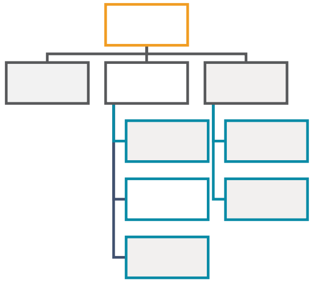


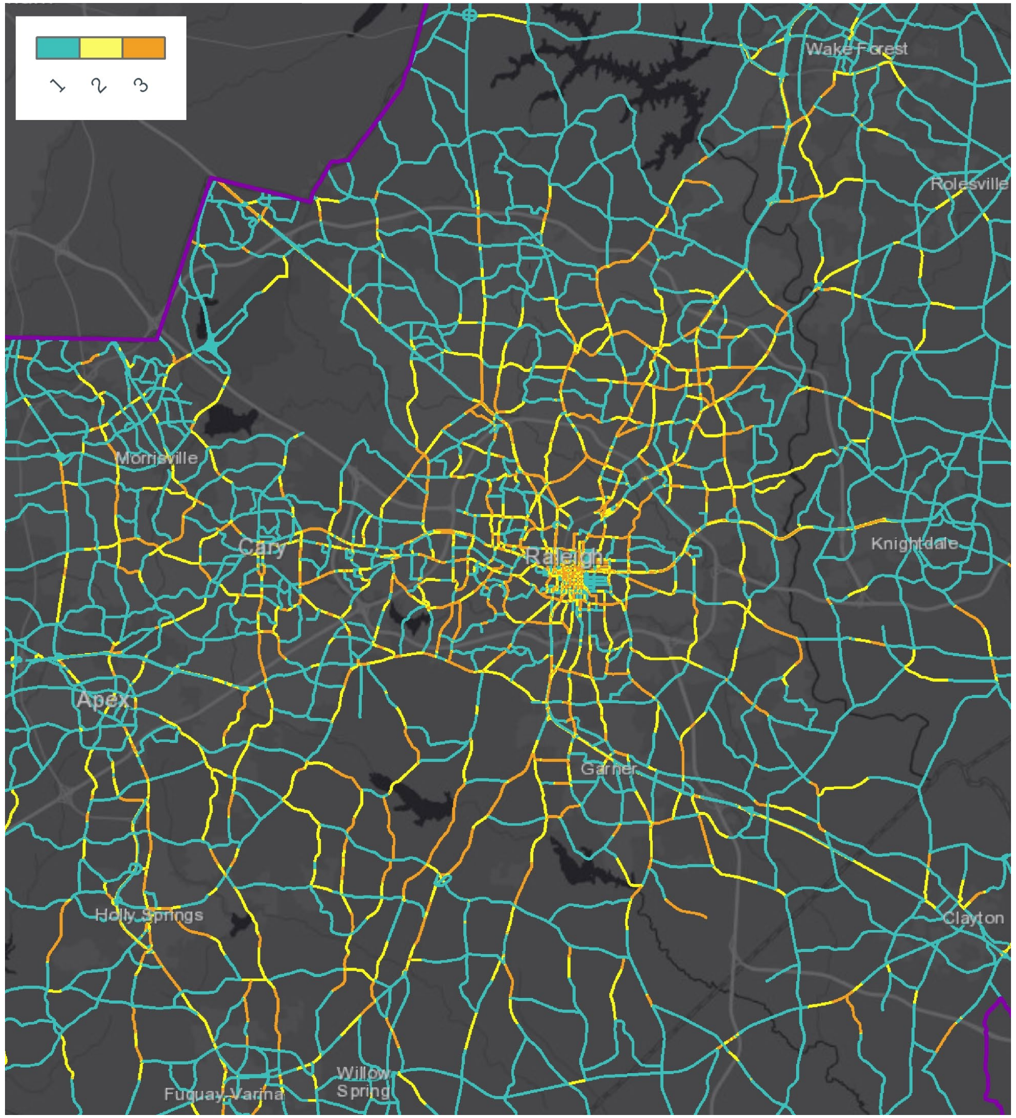
TSP SUITABILITY – V/C RATIO

Measure: V/C Ratio (2045)

- Analysis specs:
  - Floating zone: Circle with 200’ radius

V/C Ratio	TSP Suitability Score
0 – 0.75	1
0.75 – 0.9	2
0.90 – 1.10	3
1.10 – 1.25	2
1.25+	1

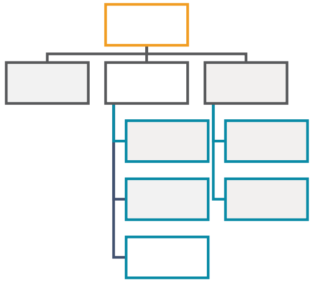




TSP SUITABILITY – TRANSIT ON-TIME PERFORMANCE

Measure: Transit on-time performance

- Rationale:
  - TSP is most appropriate in corridors where delays are contributing to on-time performance problems.
- Sources:
  - Composite on-time performance overlay from RED Lanes Suitability analysis (c. 2019)
- Methods:
  - Use the OTP overlay raster produced in the RED Lanes Suitability analysis
  - Define thresholds to set “TSP suitability tiers” based on transit on-time performance.

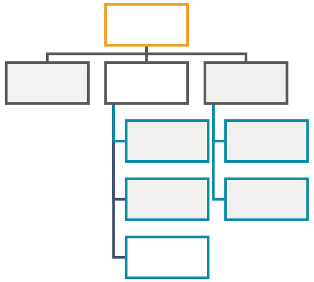


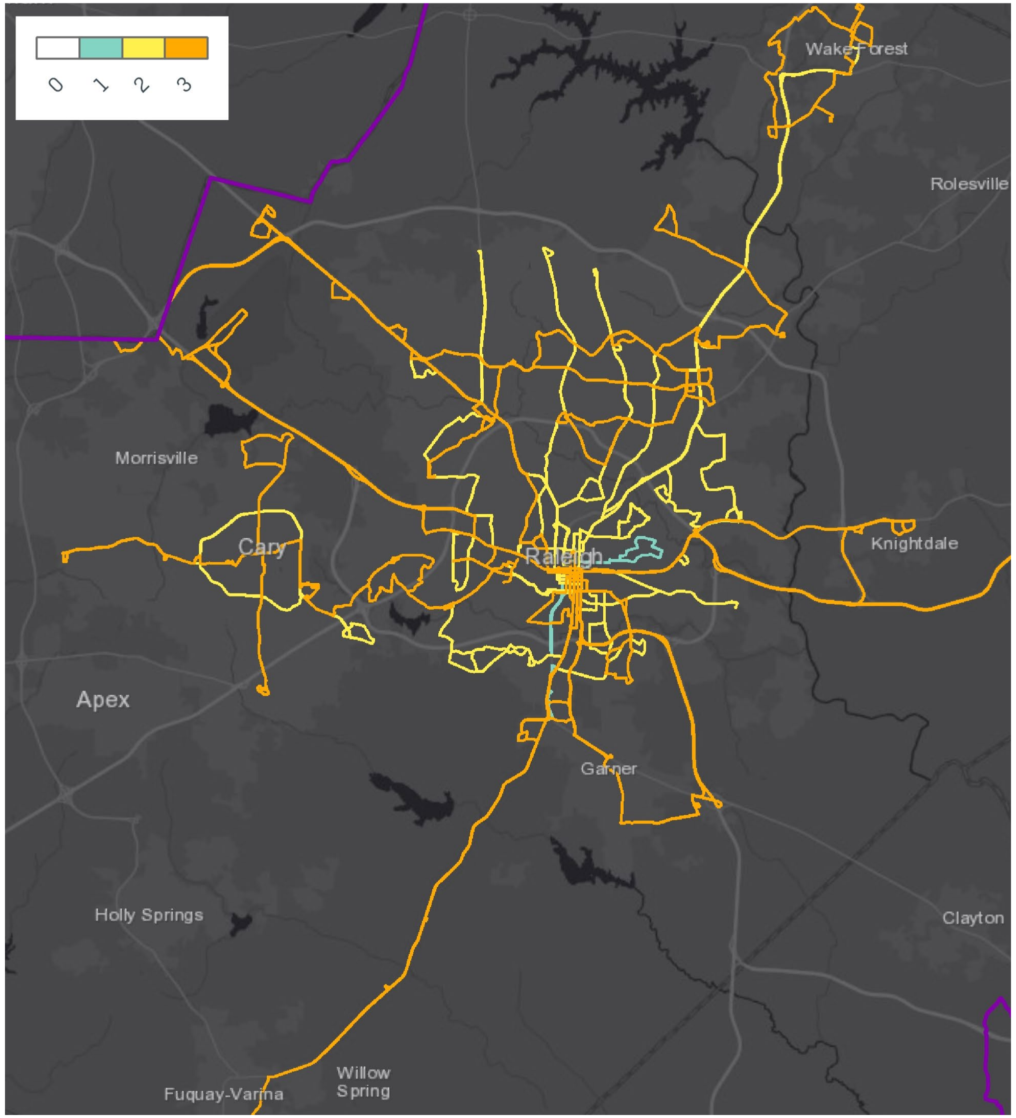
TSP SUITABILITY – TRANSIT ON-TIME PERFORMANCE

Measure: Transit on-time performance score (2019)

- Analysis specs:
  - Floating zone: Circle with 200’ radius

On-time performance score (from RED Lanes suitability analysis)	TSP Suitability Score
0	0
0 – 3	1
3 – 6	2
6 – 10	3

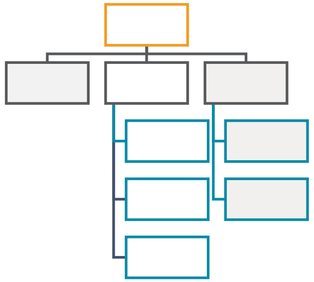


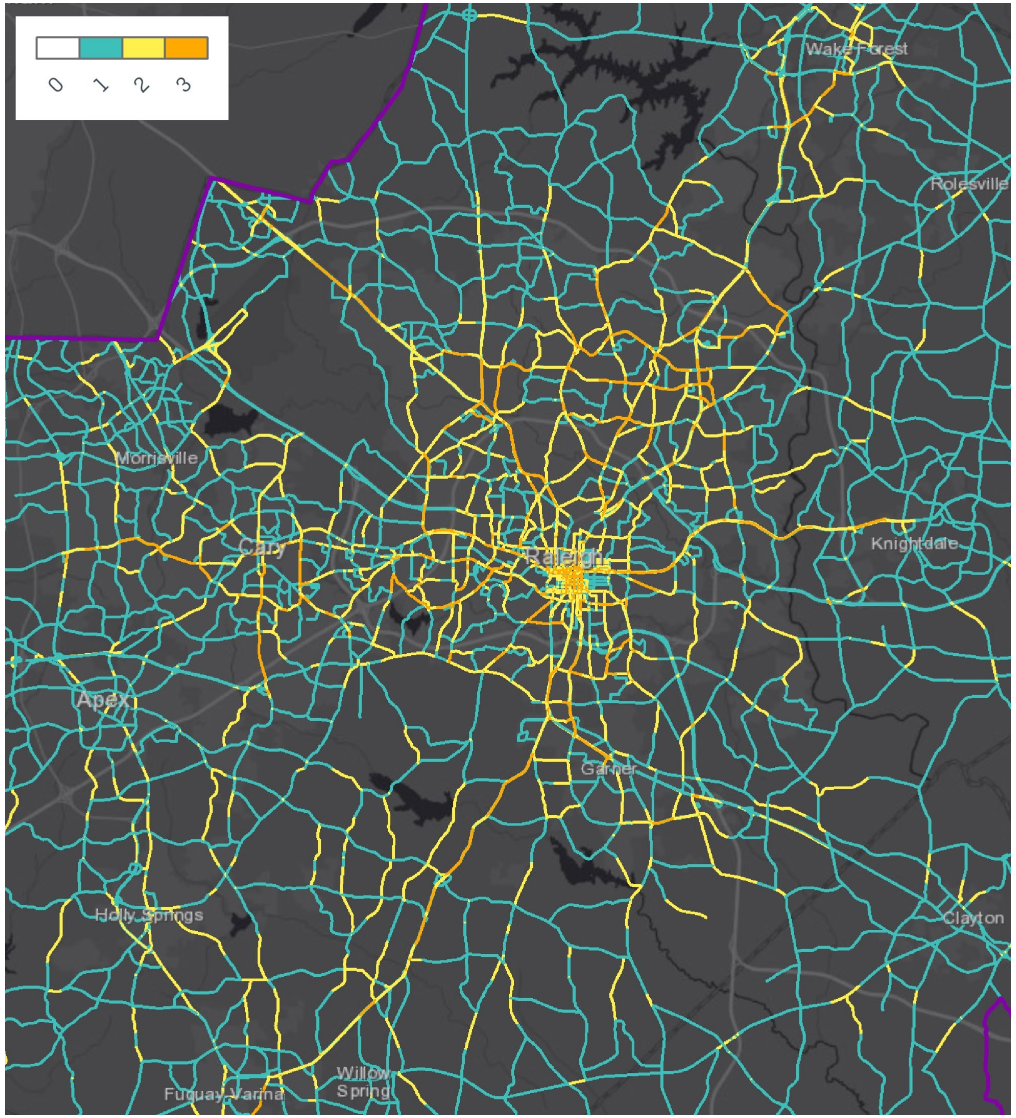


TSP SUITABILITY OVERLAY

Measure: TSP Suitability

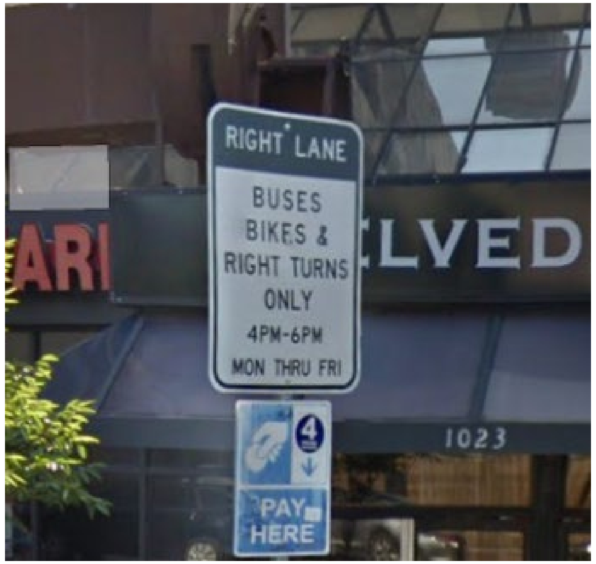
- Methods:
  - Overlay the vehicle delay, v/c ratio, and transit OTP scores and take a weighted average
    - Vehicle delay: 25%
    - V/C ratio: 40%
    - Transit on-time performance: 35%

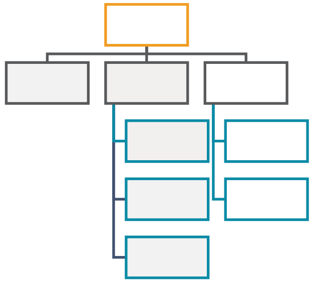




FULL-TIME SUITABILITY

- Measures:
  - Share of transit ridership in peak hours (route level)
  - Share of traffic volume in peak hours (segment level)

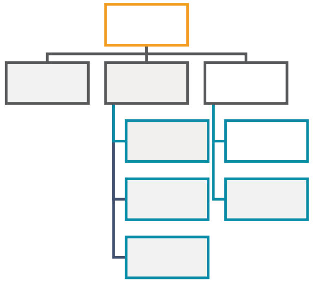




FULL-TIME SUITABILITY – TRANSIT PEAKING

Measure: Share of daily transit ridership during peak periods

- Rationale:
  - If large proportions of transit ridership occur during the peak period, the travel time and reliability benefits of RED Lanes may only be needed during peak hours. Lower proportions suggest consistent demand throughout the day warranting full-time RED Lanes.
- Sources:
  - TRM transit ridership forecasts (2045) – forecasts are available at a route level rather than a segment level.
- Methods:
  - For transit routes in the TRM, calculate the proportion of ridership occurring during the peak period (AM + PM ridership divided by daily ridership).
  - For a defined floating zone area, summarize the average peak ridership proportion
  - Define thresholds to set “Full-time suitability tiers” based on peak ridership rates.

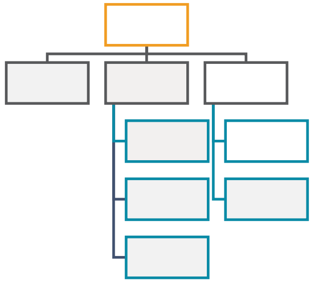


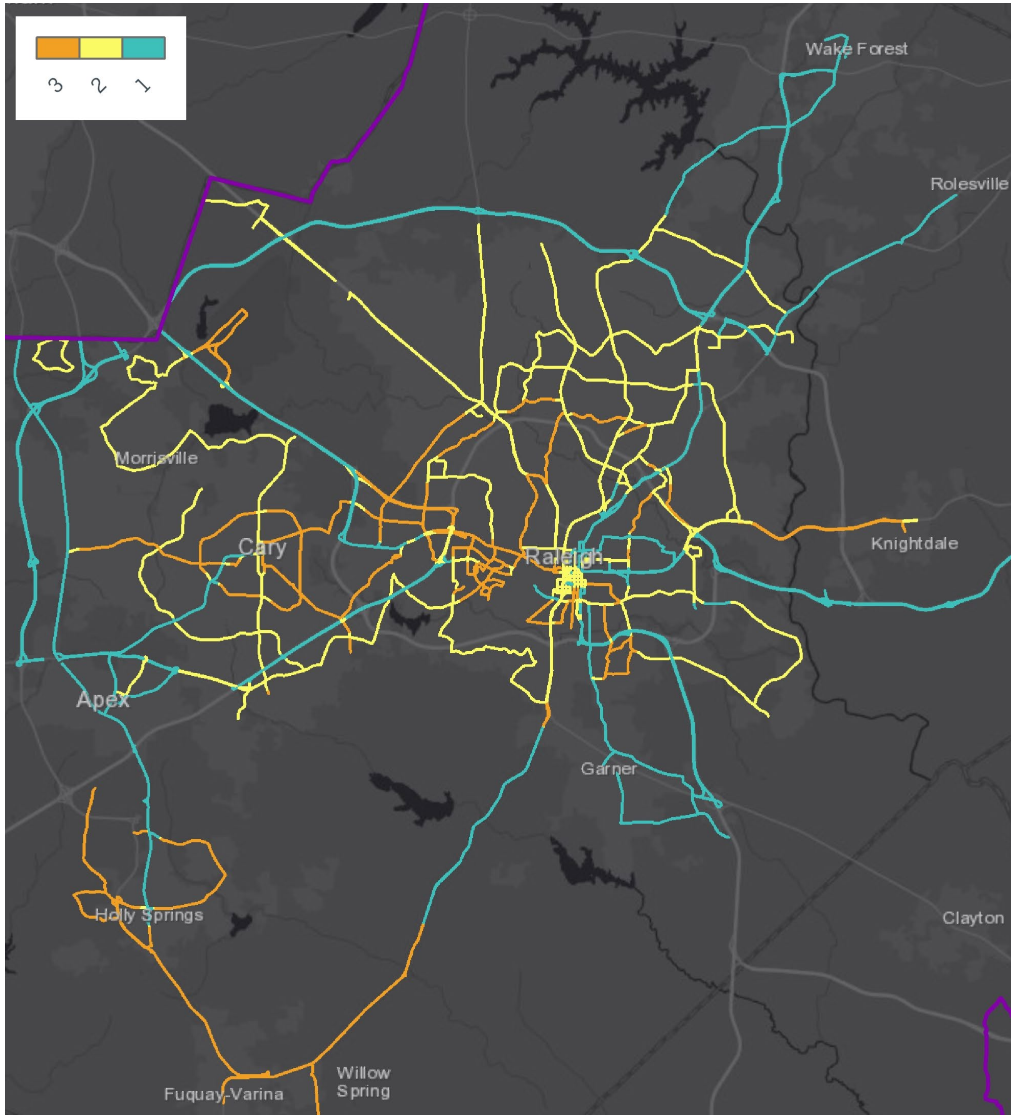
FULL-TIME SUITABILITY – TRANSIT PEAKING

Measure: Peak ridership ratio (2045)

- Analysis specs:
  - Floating zone: Circle with 200' radius

Peak Ridership Ratio Range	TSP Suitability Score
0 – 0.60	3
0.60 – 0.75	2
0.75 – 1.00	1

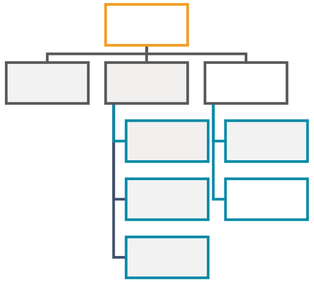




FULL-TIME SUITABILITY – TRAFFIC PEAKING

Measure: Share of daily traffic during peak periods

- Rationale:
  - Similar to transit peaking. Looking at traffic volumes in addition to transit ridership provides insight to overall demand on a segment and how it is utilized by time of day.
- Sources:
  - TRM traffic volume forecasts (2045)
- Methods:
  - For highway links in the TRM, calculate the proportion of ridership occurring during the peak period (AM + PM bi-directional volume divided by daily bidirectional volume).
  - For a defined floating zone area, summarize the average peak volume proportion
  - Define thresholds to set “Full-time suitability tiers” based on peak volume rates.

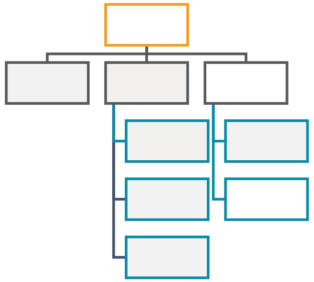


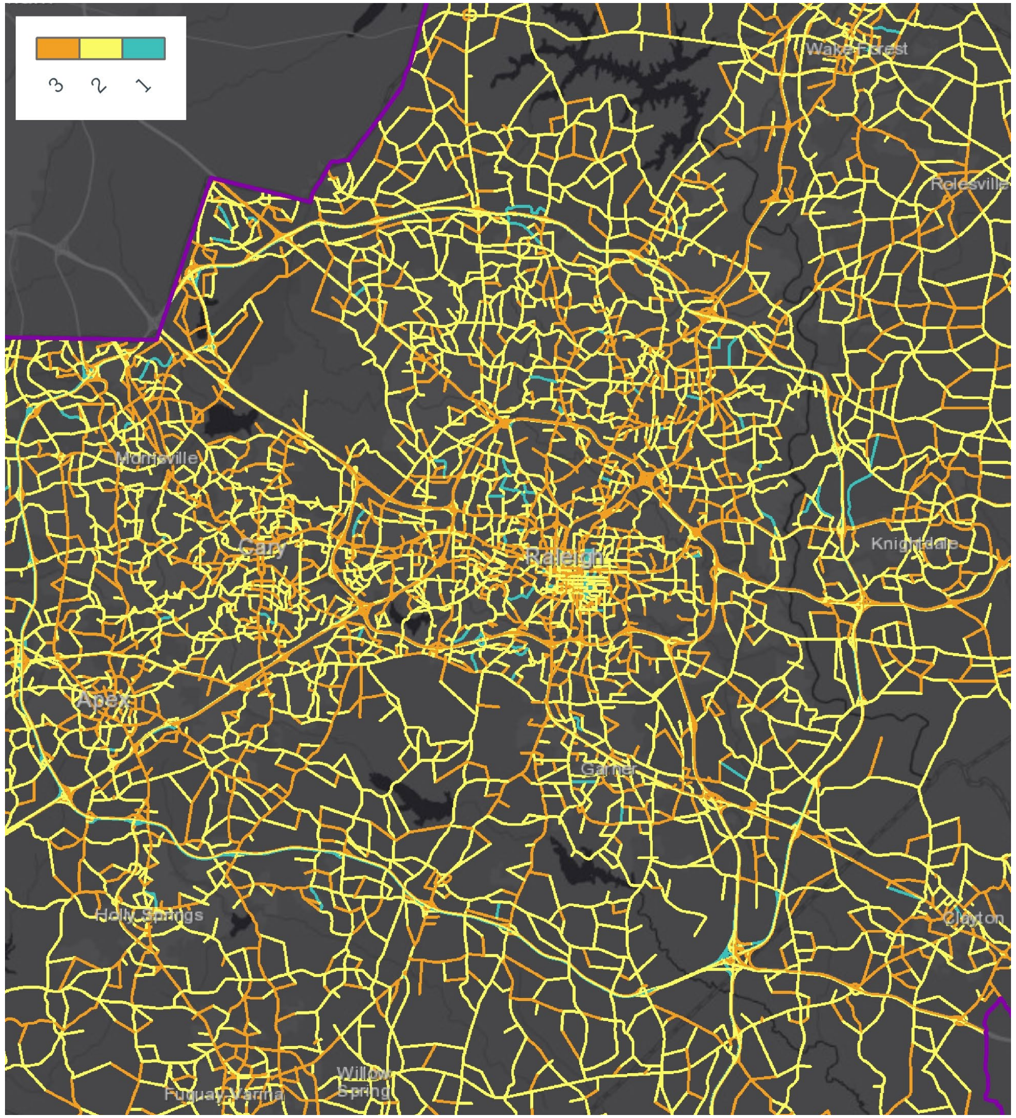
FULL-TIME SUITABILITY – TRAFFIC PEAKING

Measure: Peak volume ratio (2045)

- Analysis specs:
  - Floating zone: Circle with 200’ radius

Peak Volume Ratio Range	TSP Suitability Score
0 – 0.30	3
0.30 – 0.50	2
0.50 – 1.00	1

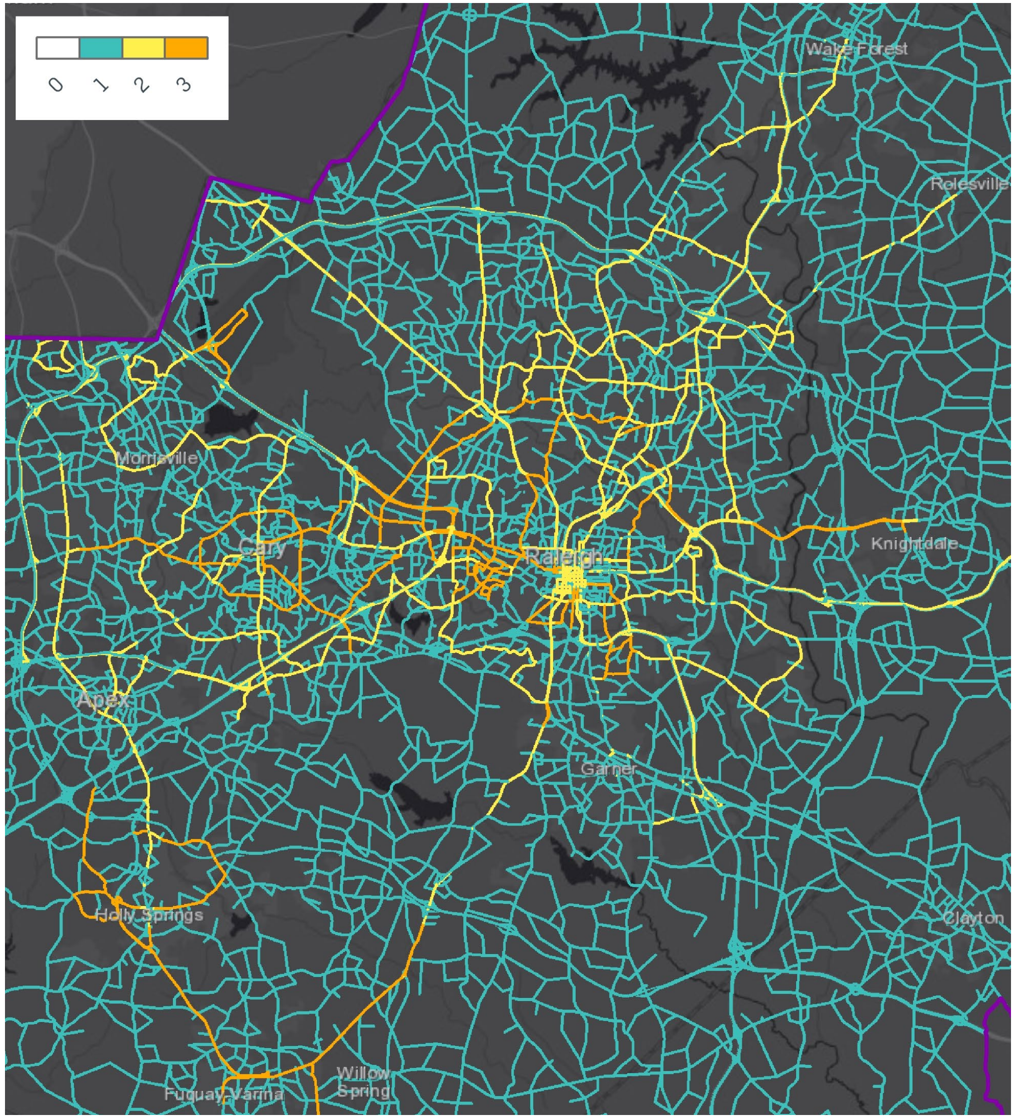


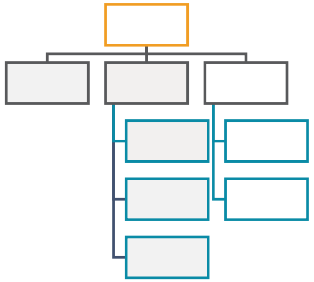


FULL-TIME SUITABILITY OVERLAY

Measure: Full-time suitability

- Methods:
  - Overlay the share of transit ridership and traffic volume in the peak periods (2045) and take a weighted average
    - Peak hour ridership proportion: 70%
    - Peak hour traffic volume proportion: 30%





4 SEGMENTATION AND REPORTING

SEGMENTATION: A 6-STEP PROCESS

1. **INTERSECT** the NCDOT Route Characteristics lines (streets) with the RED Lanes Suitability raster
2. **CLIP** the intersected streets to remove unwanted links
3. **SMOOTH** suitability values along contiguous segments
4. **BUILD INTERSECTIONS** from the NCDOT Route Characteristics streets
5. **SUMMARIZE** smoothed suitability values to intersection-constrained segments
6. **ENRICH** the segments with detailed differentiator and implementation guidance information

STEP 1: INTERSECT

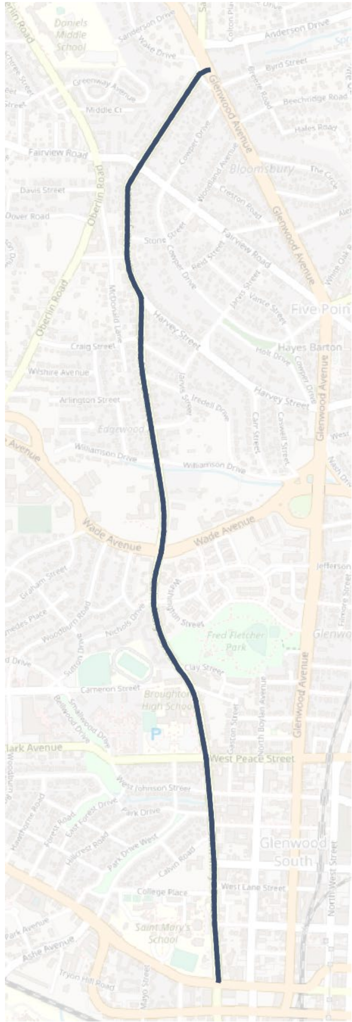
1. Generate polygon features from the suitability raster cells, focusing only on those with non-zero suitability.
2. Spatially intersect the resulting polygons with the NCDOT Route Characteristics lines.
   - This breaks each line into small pieces, each with a suitability value taken from the raster cell through which it crosses

OUTPUT: "Streets links" with unique suitability values

STEP 2: CLIP

1. Remove all street links associated with NCDOT Route IDs appearing fewer than 10 total times in the dataset
   - Segments shorter than ¼-mile total are not long enough to warrant RED Lanes.
   - Because the suitability raster consists of 100-foot cells (~140-foot diagonals), if a Route ID appears fewer than 10 times, no contiguous segments of ¼-mile or longer can exist.
2. For each remaining route ID, collect segments of contiguous links with the same ID. Remove all segments totaling less than ¼-mile.
3. For each remaining segment, if any links involve multiple route IDs, split contiguous links with matching sets of IDs into their own segment(s)
   - This step is necessary to prevent duplicative line features from disrupting downstream components of the analysis

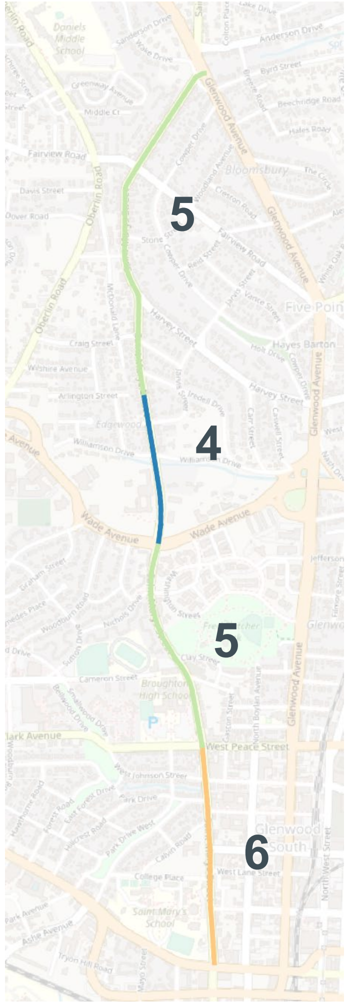
OUTPUT: “Segments” of contiguous street links of at least ¼-mile in length.



STEP 3: SMOOTH

1. For each segment, smooth the suitability values of component links by:
   1. Taking a moving window mode of suitability at each link
   2. Combining sets of contiguous links with matching moving window mode suitability values into “smoothed segments”
   3. Verifying that each smoothed segment totals at least ¼-mile (or the maximum length of the segment)
2. If the minimum length criterion is not met for all smoothed segments, increase the window size and repeat
3. Continue until all smoothed segments meet the minimum length criterion

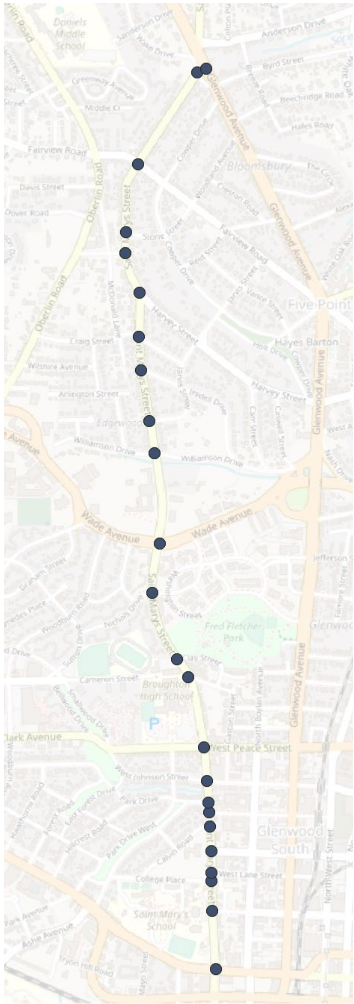
OUTPUT: “Smoothed segments” (nested within contiguous segments) with locally smoothed suitability



STEP 4: BUILD INTERSECTIONS

1. Intersect the NCDOT Route Characteristics lines with themselves. Remove resulting lines and retain only the points
   - After self-intersection, the points will represent the point where two lines meet
2. For each point, identify the two “route collections” – set of Route IDs – for the streets meeting at that point
3. Remove all points for which the two route collections match
   - This eliminates the points where a street continues onto itself, for example after a cross street (where the geometry breaks but the street itself does not)

OUTPUT: “Intersection points” of NCDOT streets in the study area



STEP 5: SUMMARIZE

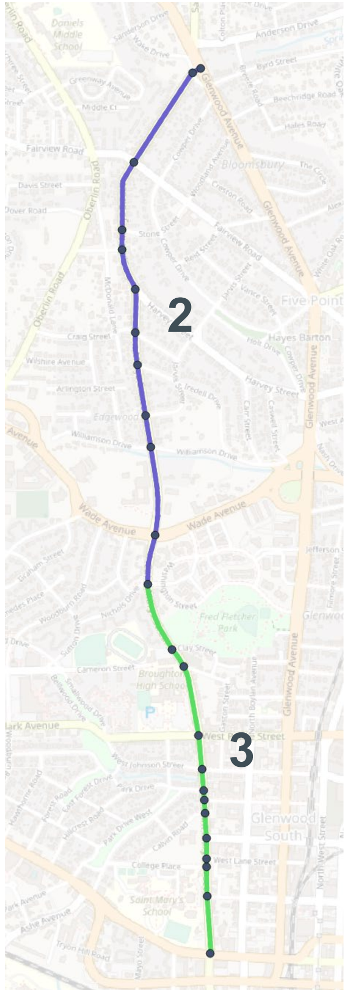
1. For each segment, identify “segment intersections” by extracting intersection points whose primary route collection matches the Route IDs found in the segment ID.
2. Use the intersections and (potentially) segment end points to construct “sections” of links between breakpoints.
3. For the first and last sections, if they do not touch an intersection, check if another segment intersection is within a distance less than the length of the section. If there is, make a note of this “extension point”; if not, remove that section.
4. Create “smoothed sections” by combining sections until a minimum of ¼ mile (or the length of the segment) is achieved. Assign an “intersection smoothed suitability” to the smoothed section by taking the smoothed suitability with the greatest total length amongst component links.
5. Create “final sections” by combining contiguous smoothed sections with the same intersection smoothed suitability.
6. Assign route names, from streets, and to streets to each final section by extracting street names from the segment intersections (or an extension point, if applicable) touched by the end links of the final section.

OUTPUT: Named “intersection smoothed segments”, where suitability is constant between street-intersection derived end points

STEP 6: ENRICH

1. For each of the detailed differentiators and implantation guidance rasters, extract values using the intersection smoothed segments
2. For each intersection smoothed segment, take the detailed differentiator and implementation guidance value as the mode of the extracted values

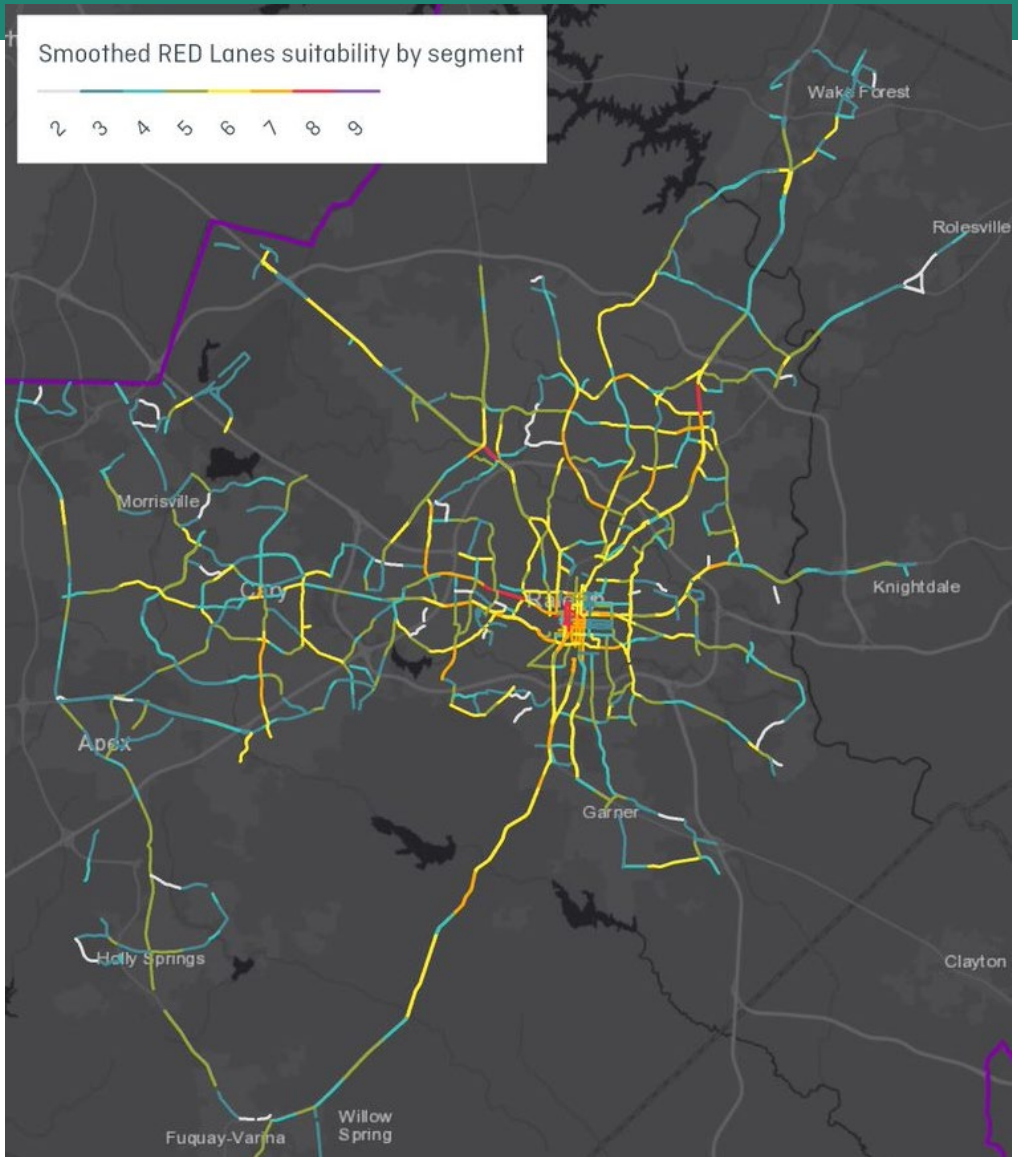
OUTPUT: Final suitability lines, with suitability, detailed differentiator, and implementation guidance values mapped to an interpretable street segment



(For detailed differentiators – communities of concern)

OUTPUT: SMOOTHED, SEGMENTED, AND ENRICHED SCORES

- Cleanly mapped segments with suitability scores, detailed differentiators, and implementation guidance measures.
- Interactive web map available here
- Tabular outputs for advanced sorting and filtering.



OUTPUT: SMOOTHED, SEGMENTED, AND ENRICHED SCORES

Segment Info			RED Lanes	Detailed Differentiators		Implementation Guidance		
Route	From	To	Suitability	Comm. Of Concern	Feasibility	Full Time Suit.	TSP Suit.	Nonmotor. Propensi
Glenwood Ave	Creedmoor Rd / Glenwood Ave	Blue Ridge Rd	9	2	2	3	2	2
Capital Blvd	Sumner Blvd	Spring Forest Rd	8	3	3	2	2	2
Capital Blvd	Spring Forest Rd	Sumner Blvd	8	3	3	2	2	2
S Blount St	E Morgan St	E Davie St	8	1	3	3	2	3
Western Blvd	Clanton St / Whitmore Dr	Varsity Dr	8	3	2	3	2	2
Glenwood Ave	Blue Ridge Rd / Lead Mine Rd	Creedmoor Rd / Glenwood Ave	8	2	2	3	2	2
E Edenton St / W Edenton St	N Person St	W Edenton St / N Mcdowell St	8	1	2	3	2	3
N Salisbury St / S Salisbury St	W Lane St / E Lane St	W Davie St	8	1	2	3	2	3
W Martin St	E Martin St / Fayetteville St	S West St	8	1	2	2	2	3
Founders Dr	Current Dr	Dan Allen Dr	8	1	2	3	3	3
N Dawson St / S Dawson St	W Lane St	W Davie St	8	1	2	3	2	3
S Mcdowell St / N Mcdowell St / Capital Blvd	W Cabarrus St	W Johnson St	8	1	2	3	2	3
Hillsborough St	Henderson St	Gardner St	8	2	1	3	3	2
	Pullen Rd	Gardner St / Hillsborough St	8	2	1	3	3	3
W Morgan St / E Morgan St	Glenwood Ave / W Morgan St	E Morgan St / S Blount St	8	1	1	3	2	3
Louisburg Rd	Capital Blvd	Batts Rd	7	3	3	2	2	2
Capital Blvd	Spring Forest Rd	E Millbrook Rd	7	3	3	3	2	2
Capital Blvd	N New Hope Rd	Spring Forest Rd	7	3	3	3	2	2
S Blount St	E Davie St	Martin Luther King Jr Blvd	7	1	3	2	3	3
Capital Blvd		Wade Ave / Capital Blvd	7	1	3	1	2	2
Capital Blvd	Old Buffaloe Rd	Louisburg Rd / Capital Blvd	7	1	3	2	2	2
Capital Blvd	Capital Blvd	Old Buffaloe Rd	7	1	3	2	2	2
Western Blvd	Crossover	Martin Luther King Jr Blvd / Martin Luther I	7	3	2	2	2	3
S Wilmington St	S Wilmington St	I 40 WB	7	3	2	2	3	3
Blue Ridge Rd	Lake Boone Trl	Macon Pond Rd	7	3	2	3	2	3
S Person St / N Person St	Hoke St	E Edenton St	7	3	2	3	2	3
E Millbrook Rd	E Millbrook Rd	Capital Blvd	7	3	2	3	2	2
Poole Rd / E Edenton St	Poole Rd / New Bern Ave	N Person St	7	3	2	2	1	3
New Bern Ave	Seawell Ave	Heath St	7	3	2	2	2	3
Martin Luther King Jr Blvd	S Wilmington St	Ellington St	7	3	2	2	2	3
Martin Luther King Jr Blvd	Holmes St / Chavis Way	Rock Quarry Rd	7	3	2	3	2	3
Shanta Dr / Sunnybrook Rd	Shanta Dr / New Bern Ave	Holston Ln	7	3	2	2	2	3
S Wilmington St	Keeter Center Dr / City Farm Rd	S Wilmington St	7	3	2	2	3	3
Glenwood Ave	Hillsborough St / Glenwood Ave	Glenwood Ave / W Peace St	7	3	2	3	2	3
S Saunders St	S Saunders St / Lake Wheeler Rd	W Lenoir St / S Saunders St	7	3	2	2	2	3
S Salisbury St / S Wilmington St	W Davie St	S Wilmington St	7	3	2	2	1	3
Keeter Center Dr	City Farm Rd / S Wilmington St	MCLENDON ST	7	3	2	2	3	3
Blue Ridge Rd	Blue Ridge Rd / Duraleigh Rd	Forestview Rd	7	3	2	3	2	3
N New Hope Rd / E Millbrook Rd	N New Hope Rd / Capital Blvd	E Millbrook Rd	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

REPORT 5: RED LANES TOOLKIT USER GUIDE

RED Priority Bus Lanes Study

RED Lanes Toolkit User Guide

June 2020

CAMPO
NC Capital Area Metropolitan Planning Organization

RENAISSANCE PLANNING

WSP

CONTENTS

1 REVIEW OF OBJECTIVES AND APPROACH

See RED Lanes Evaluation Methodology Report for details

OBJECTIVES OF THE RED LANES TOOLKIT

For a given location, assign a value that reflects its suitability for RED Lanes, differentiated by travel demand, transportation system operations, and area design/context characteristics.

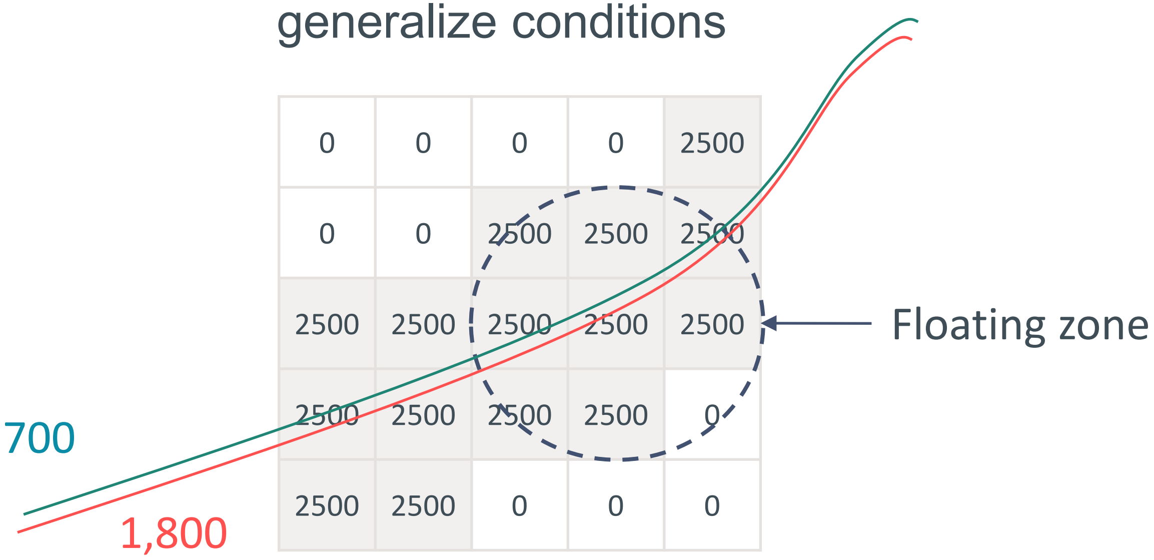
1. Major dimensions of RED Lanes suitability + enrichment elements for detailed differentiation and implementation guidance.
2. Analyze conditions on an "areawide" basis to address inconsistencies in the details of line geometries.
3. Create a consistent, predictable, and replicable process.
    - Facilitate testing of measures
    - Simplify updates to accommodate new/fresh data
    - Allow CAMPO and partner agencies to engage with and revise the RED Lanes Suitability process

APPROACH – DIMENSIONS

1. Major dimensions of RED Lanes suitability.
   a. Details of data sources, scoring rubrics, processing concepts are available in the RED Lanes Evaluation Methodology Report
   b. Suitability dimensions
      a. Travel demand
      b. Transit operations
      c. Highway operations
      d. Context and design
   c. Enrichment variables
      a. Detailed differentiators – Feasibility and Communities of Concern
      b. Implementation Guidance – Nonmotorized propensity, TSP suitability, full-time suitability

APPROACH – METHODS FOR MEASURING DIMENSIONS

2. Account for areawide conditions when measuring each dimension.
   a. Utilize spatial analysis to estimate typical conditions in a given area revealed by various linear datasets.
      - Since not all lines are digitized consistently, it is important to consider all lines within a small area to combine measures from diverse datasets.
      - Define "floating zones" as areas for which all available data points will be aggregated to generalize conditions



The blue line and the red line represent the same facility but have inconsistent GIS representation.

The blue line shows 700 transit riders on route A; the red 1,800 riders on route B.

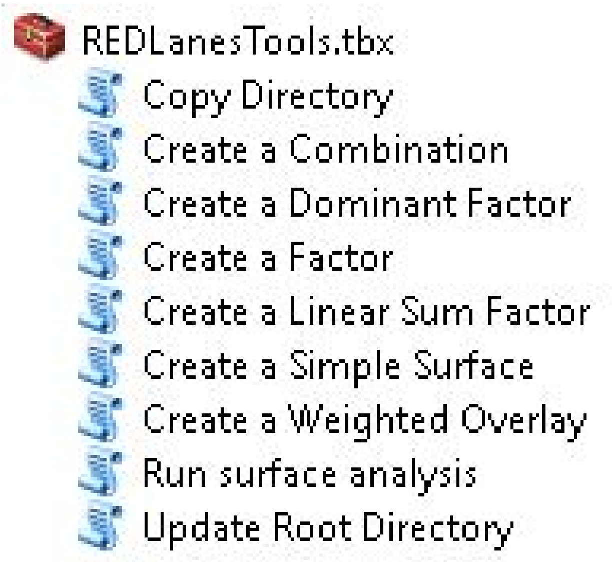
The total ridership within the floating zone is… 2,500.

APPROACH – STREAMLINING PROCESSES

3. Create a consistent, predictable, and reliable process.
   a. Utilize standard geo-processing tools to develop measures.
      - ArcGIS's Spatial Analyst extension
   b. Develop scripted process to sequence geo-processing tasks and minimize the effort required to (re)run, modify, and update suitability estimates
      - Python (arcpy)
   - Provide a simple interface for ease of use
      - ArcMap geoprocessing script interfaces

TOOLKIT OVERVIEW

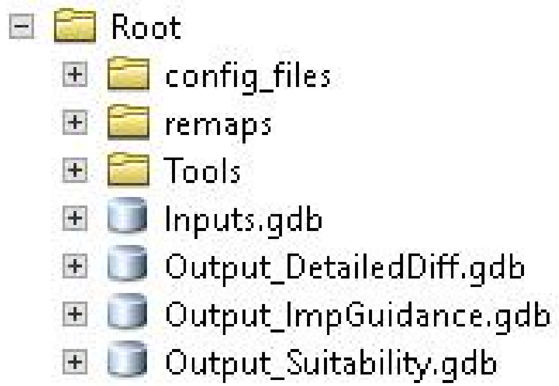
- The evaluation objectives are achieved through an ArcGIS-based Python toolkit
- The toolkit consists of several geoprocessing tools, most of which focus on developing configuration files (.json format) that guide spatial analysis procedures.
- Some tools are used for data transfer and version management.



2 DATA AND WORKSPACE PREPARATION

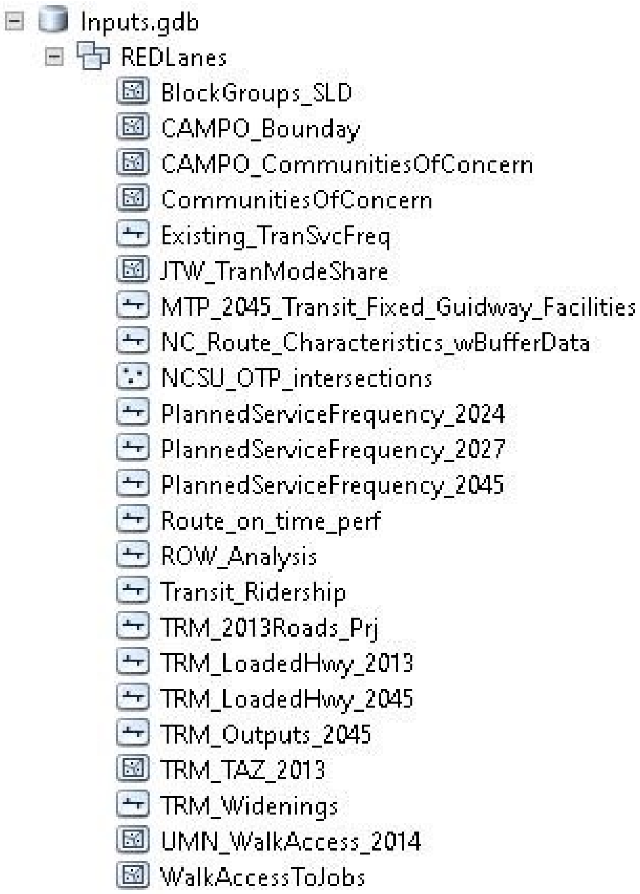
WORKSPACE ORGANIZATION – EVERYTHING IN ONE ROOT

- {Root directory}
    - Configuration files
    - Inputs geodatabase
    - Output geodatabases
        - Suitability
        - Detailed Differentiators
        - Implementation Guidance
    - Remaps
        - Info table with remap files for loading raster classification details
    - Tools



WORKSPACE ORGANIZATION – “INPUTS" GEODATABASE

- Inputs geodatabase
  - Contains a single feature dataset (“REDLanes”) using the NC State Plane coordinate system (WKID: 103122)
  - All input datasets for the RED Lanes toolkit have been imported to “REDLanes”, ensuing consistent projection.
  - “REDLanes” also includes a feature class of the CAMPO boundary. This is used to ensure consistent processing extents when running the “Run Surface Analysis” tool.
- Existing Conditions Report
  - Provides background information on raw data sources, analysis metrics, and steps taken to prepare the data to be used in the RED Lanes evaluation process.



RED LANES EXISTING CONDITIONS

INTRODUCTION AND SUMMARY OF CONTENTS

PURPOSE OF REPORT

The Capital Area Metropolitan Planning Organization (CAMPO) RED Lanes Study is taking a comprehensive look at transit priority lanes as a potential part of the region’s approach to enhancing its transportation system to meet growing demand, improve transit operations, and diversify modal options for local and regional travel. RED lanes are sometimes referred to as business access and transit (BAT) lanes or transit priority lanes. Transit priority lanes are an increasingly common component of regional transportation planning and transit investment across the U.S. and around the world. They can be a cost-effective solution for improving transit operations and service reliability.

Two previous reports – *RED Lanes Fundamentals* and *Key Plans in the CAMPO Region* – defined key concepts and components of RED Lanes and highlighted prior regional planning efforts related to RED Lanes implementation, respectively. This *Existing Conditions Report* (ECR) examines existing conditions and trends across a variety of indicators to provide insight into where RED Lanes are likely to be most appropriate. The ECR builds on the findings of the previous reports, relating key indicators to best planning practices for RED lanes and grounding indicator development in relevant past or ongoing planning efforts. The data and maps developed for this report will inform later phases of the CAMPO RED Lanes Study, including the development of a RED lanes evaluation/prioritization methodology for ranking corridors in the CAMPO region according to their suitability/readiness for RED lane implementation. As such, the ECR functions both as a snapshot of regional trends and conditions affecting transit system performance and regional mobility as well as a foundational component of the RED Lanes evaluation methodology.

Figure 1. The ECR is the last step before developing the evaluation methodology and scoring tool for candidate RED lanes.

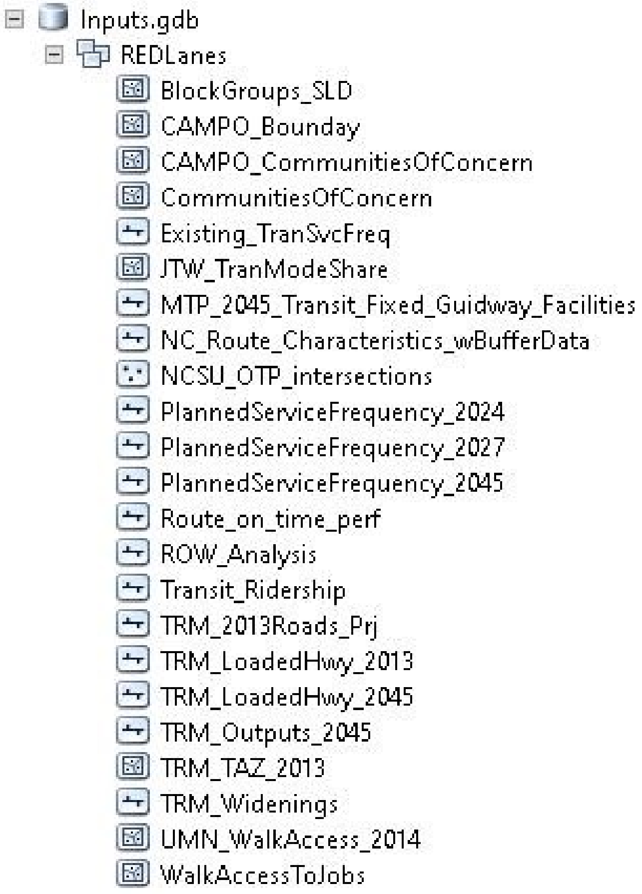
REPORT STRUCTURE

The ECR is organized into four major sections. The first section (“Key Findings”) summarizes key findings from the development and analysis of key indicators and metrics describing the performance of the regional transportation system, planned transit operations, facility contexts, and policy considerations. These findings offer general guidance for developing the RED Lanes evaluation methodology in the next phase of the RED Lanes Study.

Existing Conditions Report
Introduction and Summary of Contents
1
DRAFT May 31, 2019

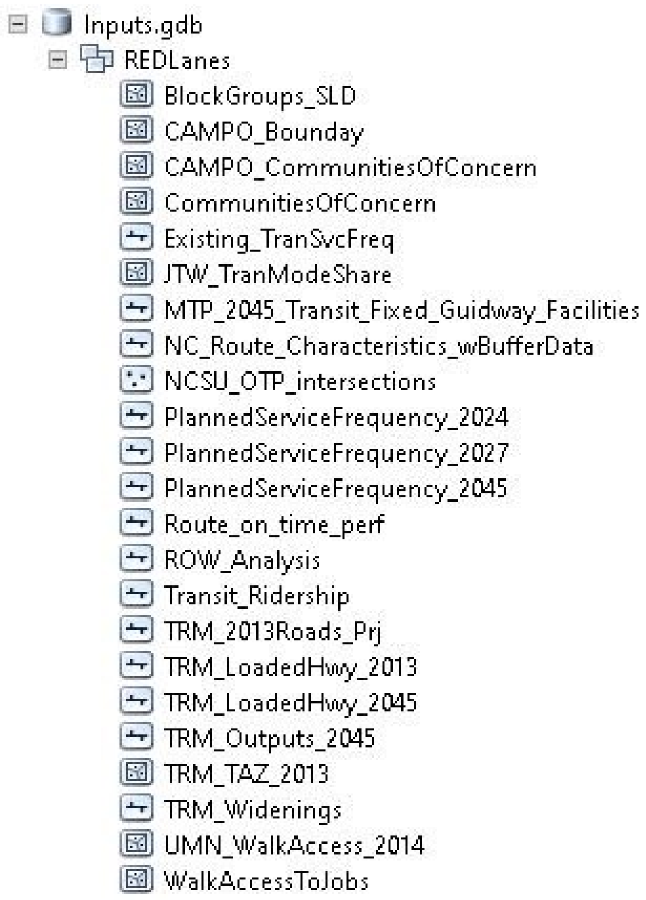
INPUTS DETAILS

- Input geodatabase
  - BlockGroups_SLD
    - Source: EPA Smart Location Database extract
    - Use: intersection density (field=D3b)
  - CAMPO_Boundary:
    - Source: CAMPO
    - Use: set consistent processing extents for all surfaces
  - CAMPO_CommunitiesOfConcern
    - Source: CAMPO
    - Use: number of communities of concern served (field=overlap_count)
  - Existing_TranSvcFreq
    - Source: Wake Bus Plan GIS files
    - Use: existing number of buses per hour on each segment during peak (field=BusPerHrPk).
  - MTP_2045_Transit_Fixed_Guideway_Facilities
    - Source: CAMPO
    - Use: masking suitability results for corridors with fixed guideway ongoing studies



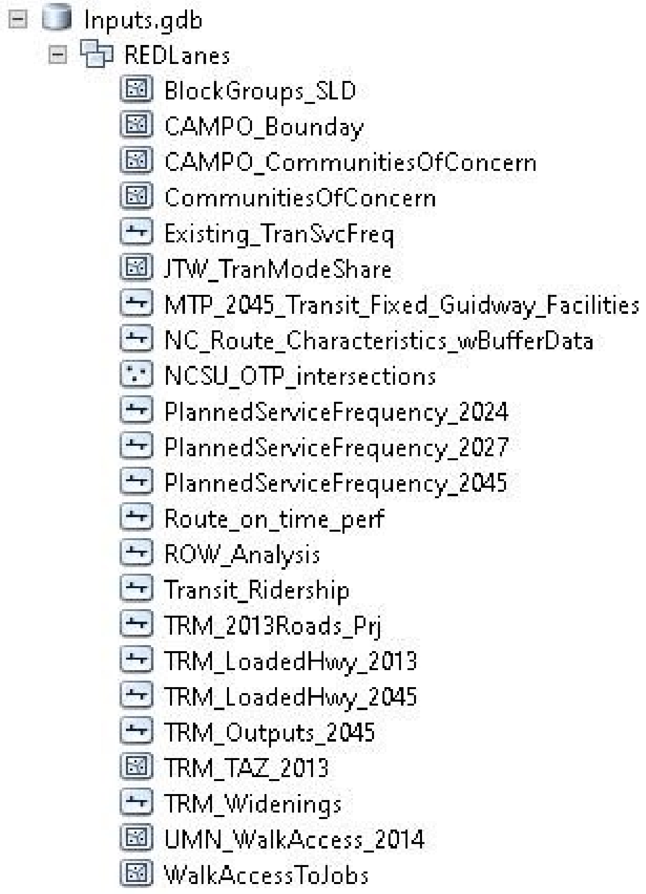
INPUTS DETAILS (cont.)

- Input geodatabase
  - NCSU_OTP_intersections
    - Source: generated as part of the RED Lanes study based on input from NCSU Wolfline staff
    - Use: Highlight intersections that cause on-time performance issues for Wolfline buses.
  - PlannedServiceFrequency_{year}
    - Source: Wake Bus Plan GIS files, MTP
    - Use: number of buses per hour on each segment during peak in the named year (field=BusPerHrPk).
  - Route_on_time_perf
    - Source: generated as part of RED Lanes study based on transit agency route shape files and on-time performance tables.
    - Use: Route-level on-time performance rates (field=Pct_OnTime)
  - ROW Analysis
    - Source: generated as part of RED Lanes study based on NCDOT route characteristics shape file and Microsoft Building Footprints database.
    - Use: ROW analysis for feasibility ranking (field=bld_pr_mi)



INPUTS DETAILS (cont.)

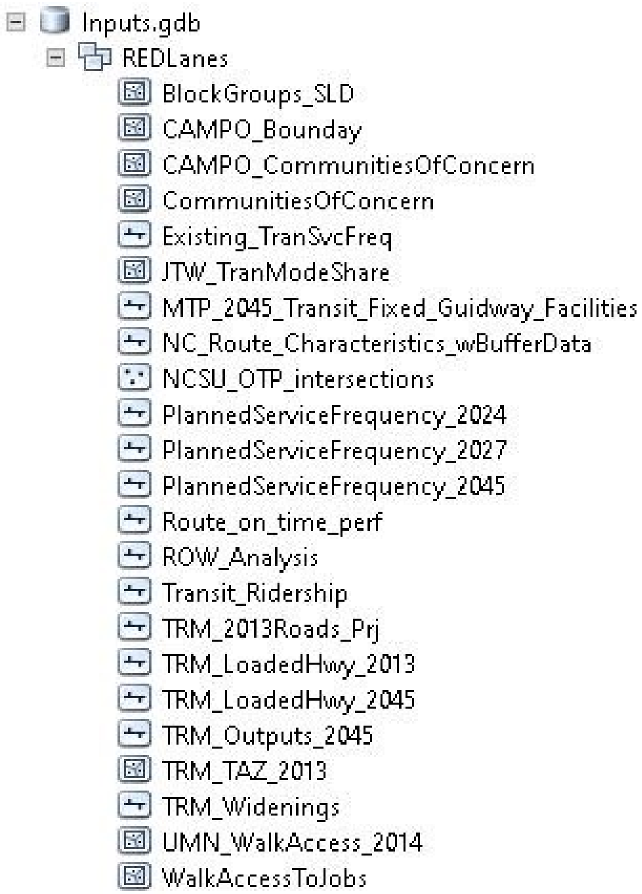
- Input geodatabase
  - Transit Ridership
    - Source: Triangle Regional Model
    - Use: Route-level peak and daily ridership forecasts in 2045 (fields=DAILY_RIDERS, PK_SHR_R)
  - TRM_2013Roads_prj
    - Source: Triangle Regional Model
    - Use: Number of lanes data for feasibility ranking (field=LANESDIR)
  - TRM_LoadedHwy_2045
    - Source: Triangle Regional Model (NCSU segment flag added manually as part of RED Lanes study based on input from NCSU Wolfline staff)
    - Use: Traffic volume (TOTDLYVOL), bus speed (MIN_PK_BUS_SPD), vehicle delay (MIN_PM_CFF_SPND), v/c ratio (MAX_PM_VC), segments that routinely pose on-time performance challenges for Wolfline routes (NCSU_OTP)
  - TRM_Outputs_2045
    - Source: Triangle Regional Model
    - Use: Peak-hour volume shares for full-time-suitability ranking (field=PM_SHARE)



Note: multiple extracts of TRM data were used throughout the development of RED Lanes evaluation process. It is likely the many feature classes listed here could be consolidated in a smaller number of extracts.

INPUTS DETAILS (cont.)

- Input geodatabase
  - TRM_TAZ_2013
    - Source: Triangle Regional Model
    - Use: Activity-unit density (field=AU_DENSITY)
  - UMN_WalkAccess_2014
    - Source: University of Minnesota Accessibility Observatory
    - Use: Walk access to jobs for nonmotorized propensity ranking (field=JT_LONG)



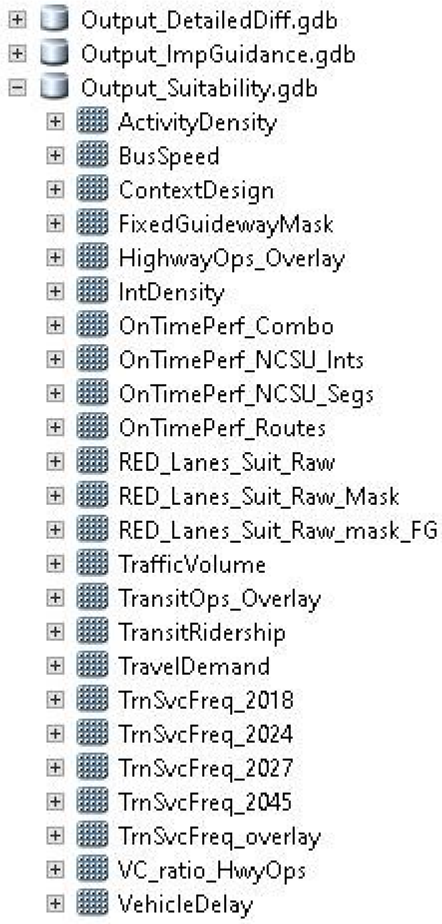
WORKSPACE ORGANIZATION – CONFIGURATION FILES

```
Root
  config_files
    ActivityDensity.json
    BusSpeed.json
    ContextDesign.json
    DD_Combo.json
    DD_ComboMasked.json
    DD_CommunitiesOfConcern.json
    DD_Feasibility_NumberLanes.json
    DD_Feasibility_Overlay.json
    DD_Feasibility_ROW.json
    DD_Feasibility_Widening.json
    DD_SuitMask.json
    FixedGuidewayMask.json
  remaps
  Tools
  Inputs.gdb
  Output_DetailedDiff.gdb
  Output_ImpGuidance.gdb
  Output_Suitability.gdb
```

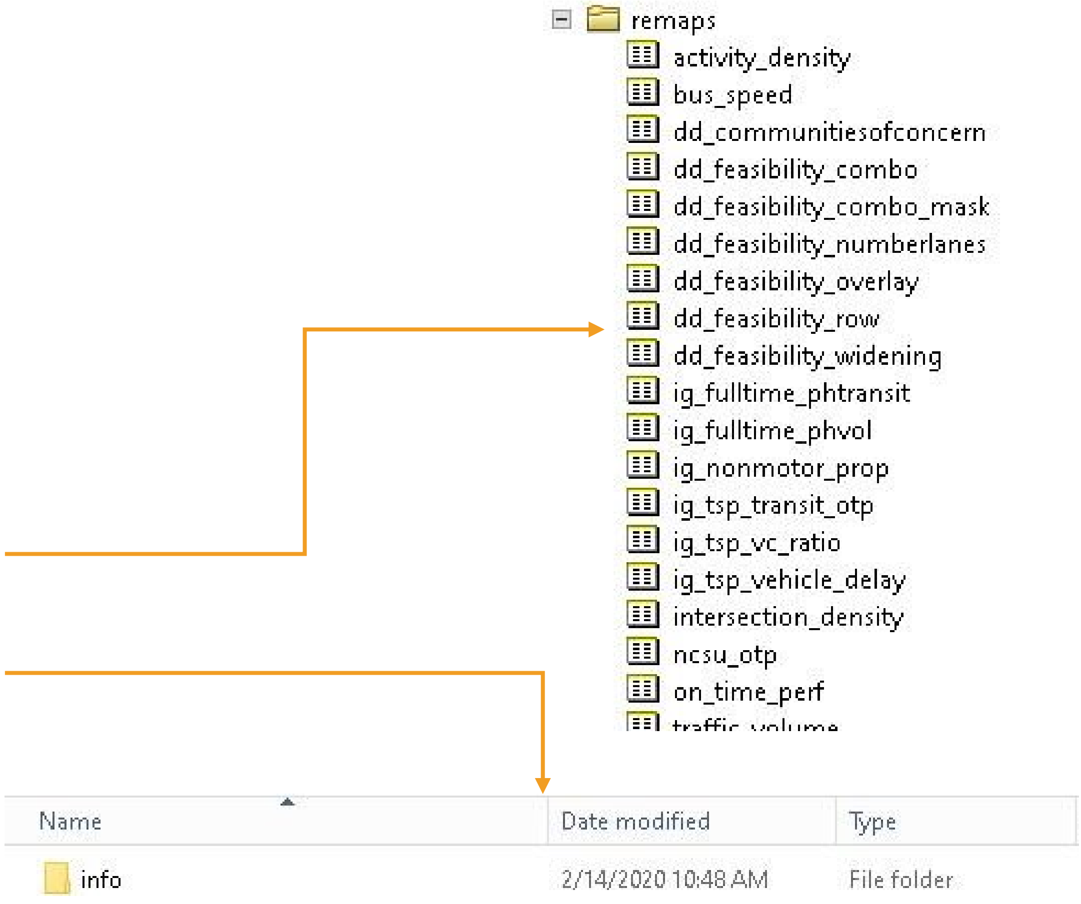
- Configuration files store information about surface objects:
  - Where source data are stored (the inputs geodatabase, e.g.)
  - Dependencies on other surface objects (an overlay that depends on two factors, e.g.)
  - Processing parameters and reclassification specifications
- Use the "**Run Surface Analysis**" tool to create the resulting raster for the specified surface configuration (.json) file as well as all prerequisite files. (Warning! All existing files in the output geodatabase are deleted when this tool is run.)

WORKSPACE ORGANIZATION – OUTPUTS

- Output surfaces must be written to a geodatabase
- There are three separate output geodatabases for the RED Lanes evaluation process:
  - Output_Suitability: contains all rasters pertaining to RED Lanes Suitability (example to right)
  - Output_DetailedDiff: contains all rasters pertaining to the development of Detailed Differentiator measures
  - Output_ImpGuidance: contains all rasters pertaining to the development of Implementation Guidance measures

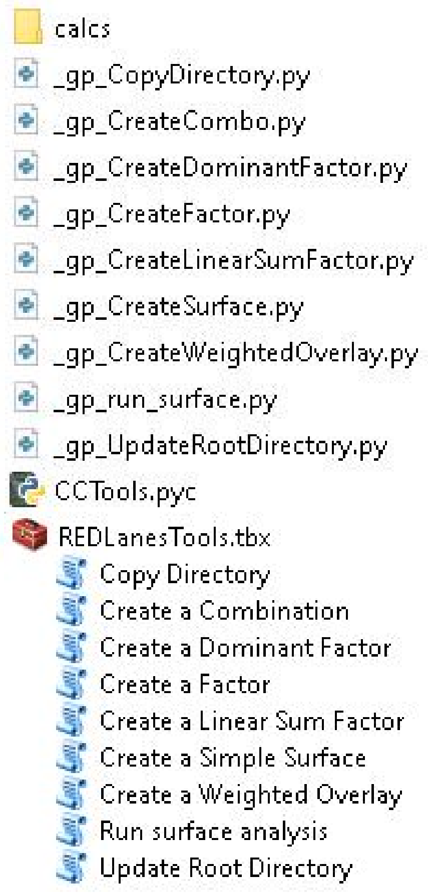


- A key component of the evaluation process and each configuration file is the potential need to reclassify rasters. For example, continuous-value estimates of transit ridership by route are classified into 10 ordinal RED Lanes suitability scores.
- Reclassification details can be saved to/loaded from an ArcGIS INFO table. The remaps folder contains the INFO table and a collection of reclassification subtables.
    - In ArcCatalog, these appear as tables within the remaps folder.
    - In the file system, these appear as a folder called “info” with a collection of files inside it.
- These simplify the process of reviewing and updating configuration files and will be discussed further in the next section.



WORKSPACE ORGANIZATION – TOOLS

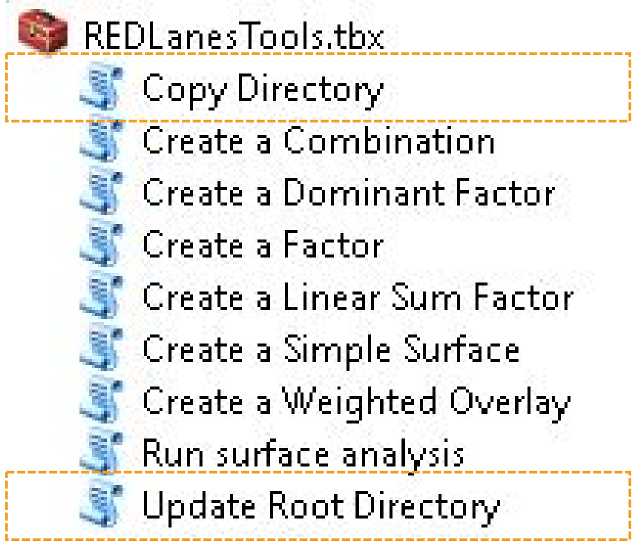
- The tools directory contains the RED Lanes toolbox and supporting resources, including
  - Calcs folder – contains calculation expressions for use in ArcGIS field calculation. These support input data preparation (processing native TRM fields to populate a user-added field, e.g.).
  - Python scripts – the scripts that power the toolbox. Users do not need to open, edit, or run these scripts directly and are discouraged from doing so.



MANAGING AND SHARING WORKSPACES

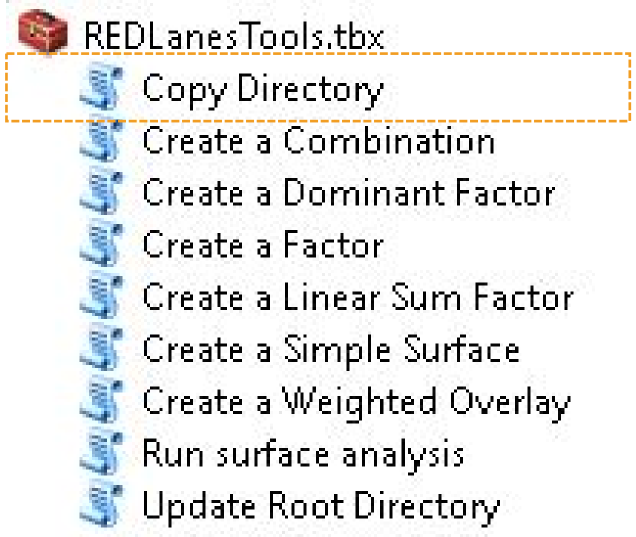
Config files contain full path references to input datasets and other config files. For this reason, moving and copying files to other root directories should be done using the RED Lanes toolbox:

- Use the **Copy Directory** tool to handle process versioning within the same root directory.
- Use the **Update Root Directory** tool when moving or replicating the process across different root directories.

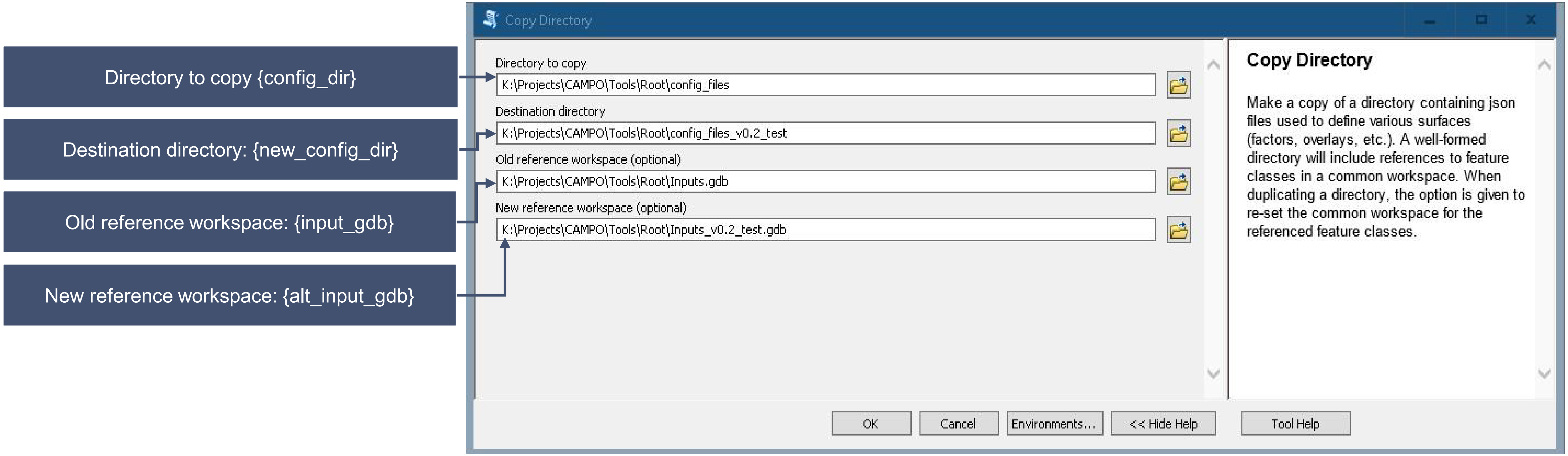


USING THE “COPY DIRECTORY” TOOL

- The process of setting up the entire set of surface configuration files can be onerous. To simplify setup for alternative versions/vintages/scenarios within the same root directory, use the “Copy Directory” tool.
- The tool copies configuration files and resets each json’s path.
- Optionally, a “reference workspace” can be reset as well. This can be the root directory or a subdirectory (like an alternative “inputs” geodatabase, e.g.).
  - Use this option if copying a configuration while linking inputs to a different input geodatabase.
  - If making a copy simply to test alternative analysis parameters (but not different input data), this option is not needed.



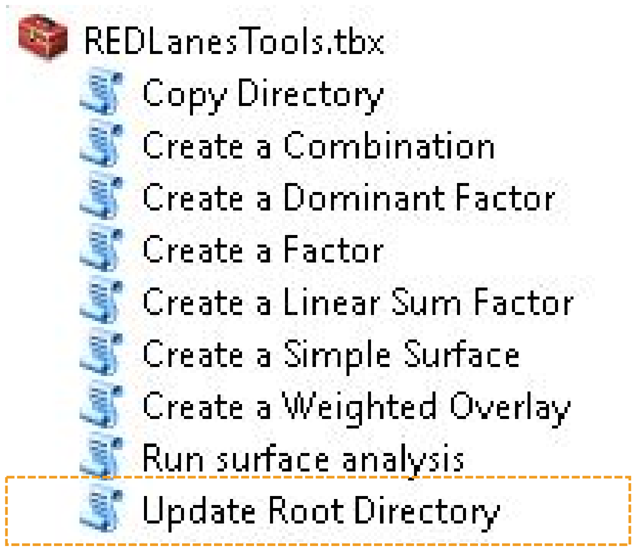
USING THE "COPY DIRECTORY" TOOL



- *The "Copy Directory" tool will generate copies of config files in the "Directory to Copy" within the "Destination Directory."*
- *In this example, the new files will need to refer to an alternative set of inputs (perhaps data updates or an alternative scenario), so the "Old Reference Workspace" and "New Reference Workspace" fields identify that previous references to "Inputs.gdb" should now point to "Inputs_v0.2_test.gdb." If these fields are blank, the new config files will continue to reference input data from the origin "Inputs.gdb"*

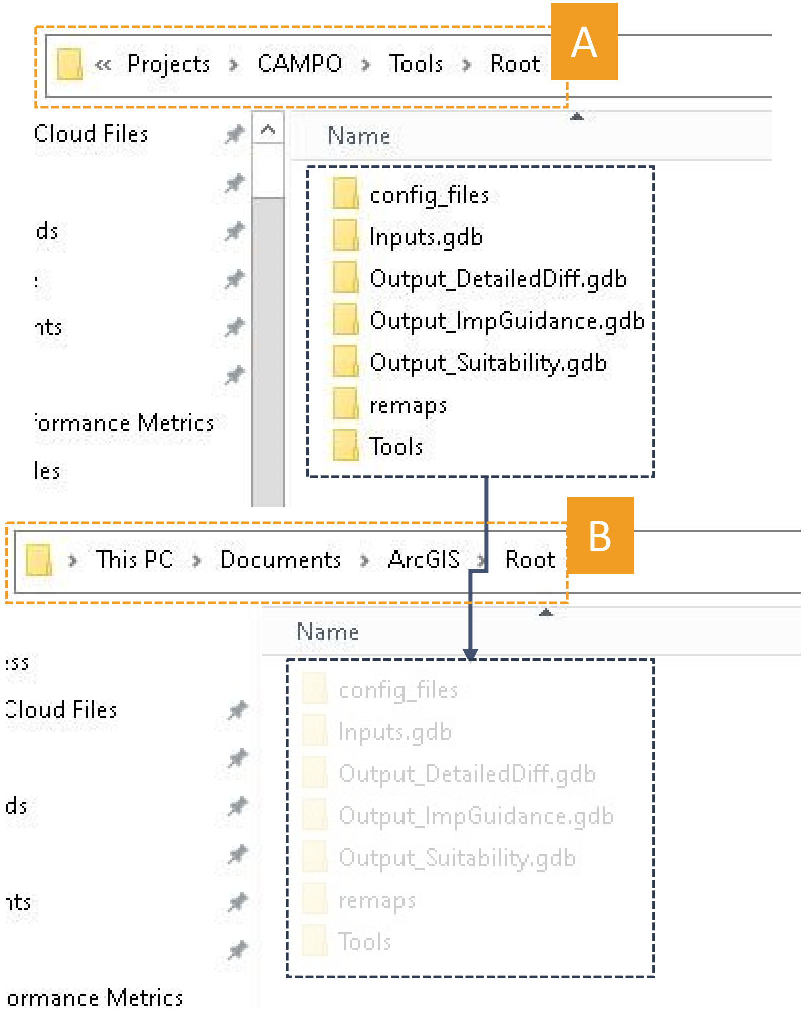
USING THE "UPDATE ROOT DIRECTORY" TOOL

- Migrating data and configuration files to a new root directory (to a new server, e.g.) requires maintaining a consistent file structure and updating the path to the root directory. The "Update Root Directory" tool simplifies this process.
- Procedure:
  1. Copy the existing root directory and all sub-folders (including input data and configuration directories) to the new root directory.
  2. Copy the path of the old root directory as the "old root directory" input into the tool dialog.



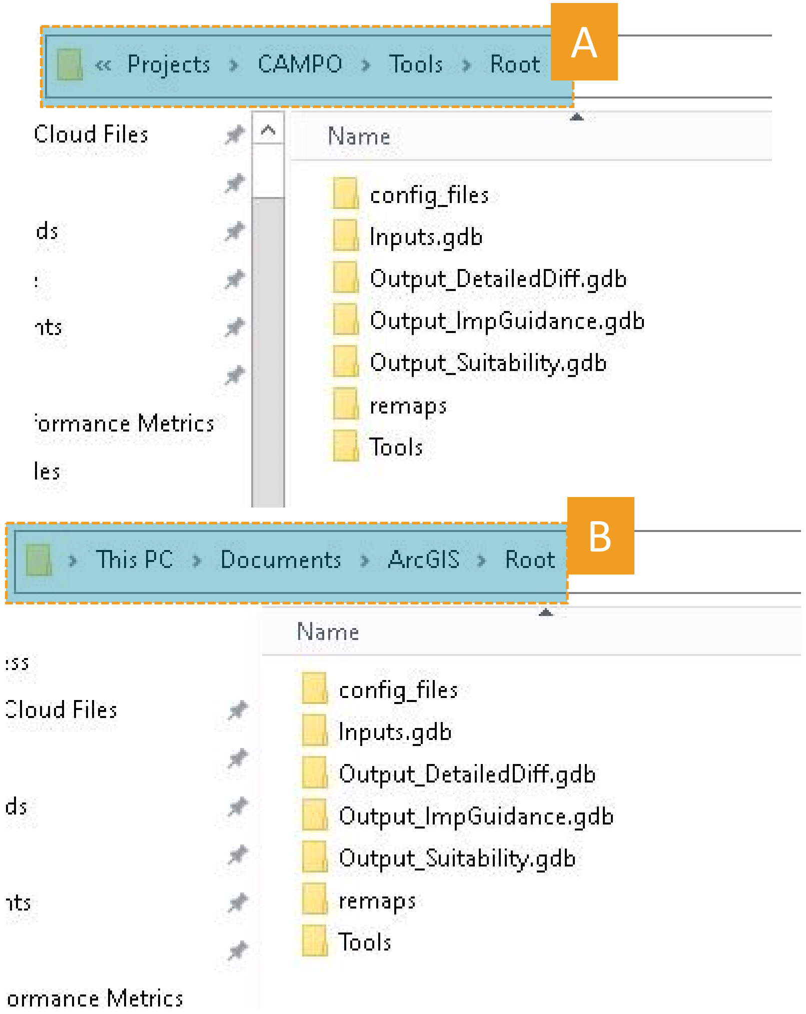
USING THE "UPDATE ROOT DIRECTORY" TOOL

- Migrating data and configuration files across folders or servers requires maintaining a consistent file structure and updating the path to the "root directory" (see "Organization of Data" slide). The "update root directory" tool helps simplify this process.
- Procedure:
  1. Using the file system, copy the existing root directory (A) and all sub-folders (including input data and configuration directories) to the new root directory (B).

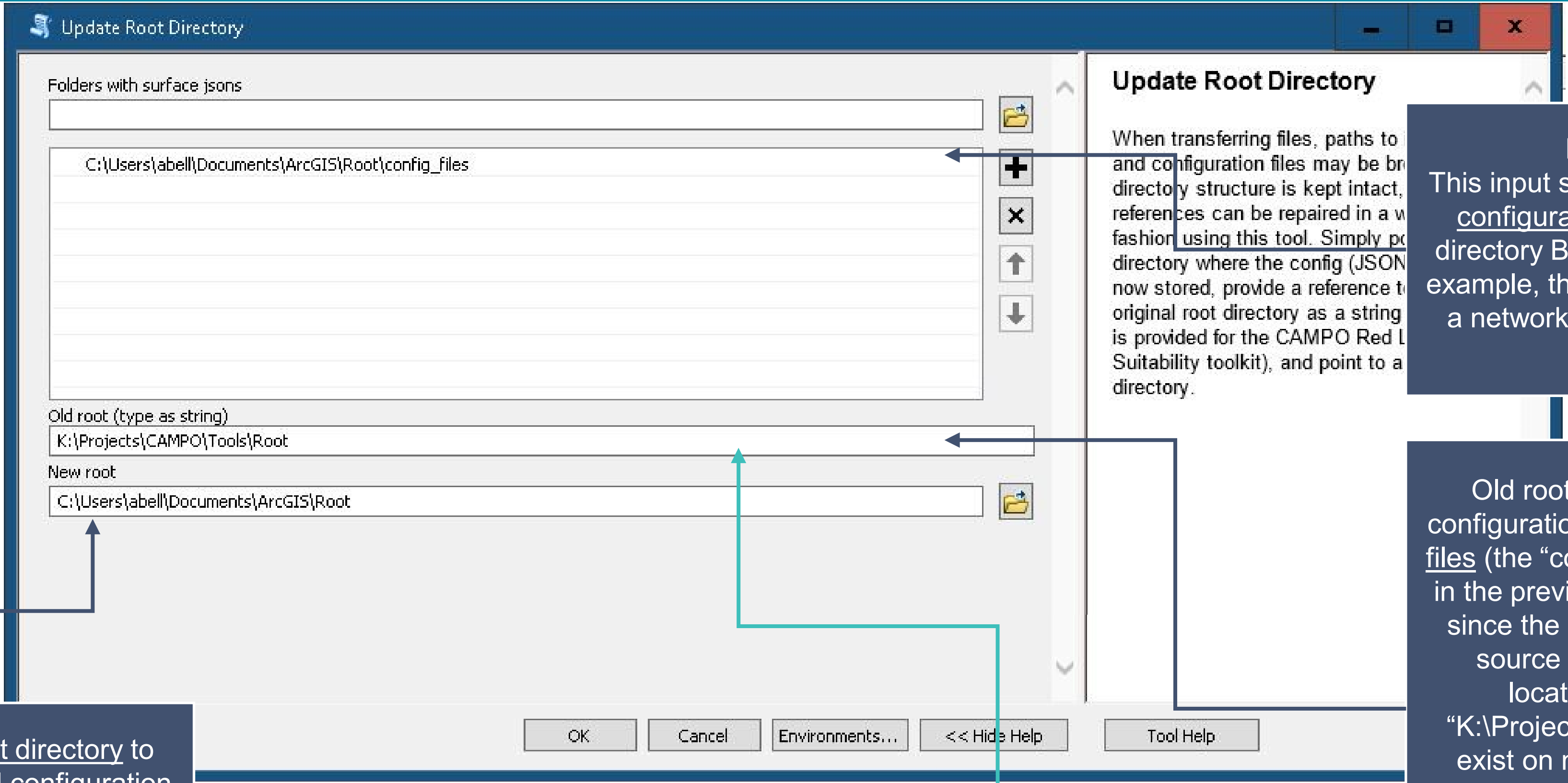


USING THE “UPDATE ROOT DIRECTORY” TOOL

- Migrating data and configuration files across folders or servers requires maintaining a consistent file structure and updating the path to the “root directory” (see “Organization of Data” slide). The “update root directory” tool helps simplify this process.
- Procedure:
  2. Copy the path of the old root directory (A) and paste it as the “old root directory” input into the tool dialog (see next slide).
  3. Copy the path of the new root directory (B) and paste it as the “new root directory” input into the tool dialog (see next slide).



USING THE "UPDATE ROOT DIRECTORY" TOOL



Folders with surface jsons:
This input should point to any folders with copied configuration files (the "config_files" folder in directory B shown in the previous slides). In this example, the root directory has been copied from a network drive (K:\Projects…) to a local drive (C:\Users…).

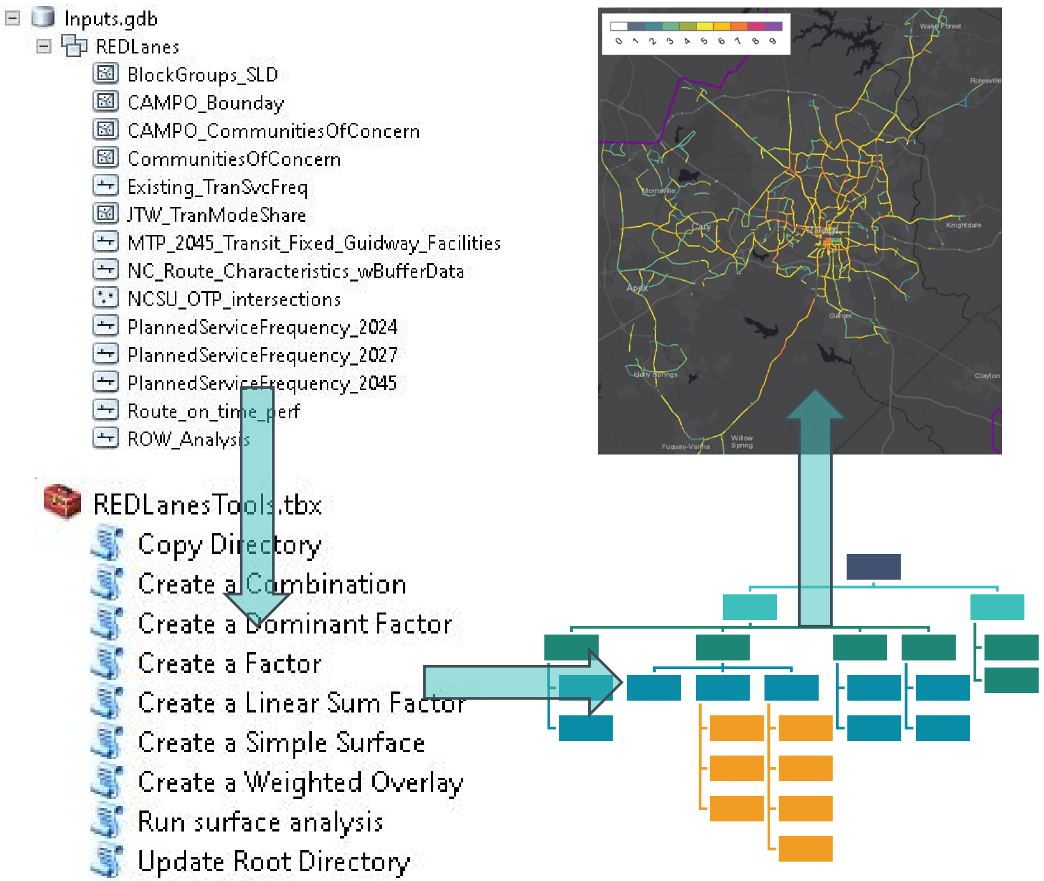
Old root: The original root directory for the configuration files in the folder(s) specified above files (the "config_files" folder in directory A shown in the previous slides). The input takes a string, since the data may be shared from an original source that is not accessible from its new location. For example, the directory "K:\Projects\CAMPO\Tools\Root" is unlikely to exist on most computers, so the user cannot simply navigate to that folder. Nevertheless that directory is still referenced by the copied json configuration files and needs to be searched for and revised to match the "new root" input (next field).

New root: The new root directory to which the input data and configuration files have been copied. References in the configuration files will be updated to point to this new location.

"K:\Projects\CAMPO\Tools\Root" is the default value in the tool interface since this is the original directory of the RED Lanes suitability config files and input data.

3 GEOPROCESSING TOOLKIT INTERFACES

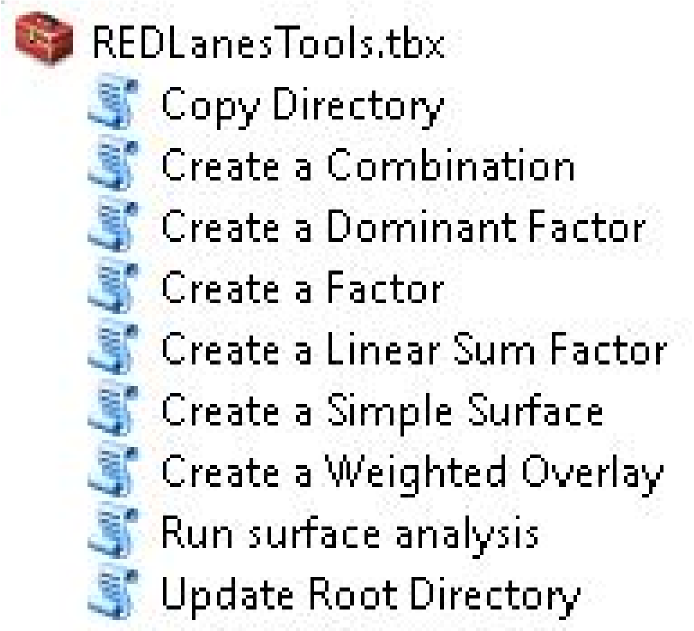
SECTION OVERVIEW



This section explains the tools in the RED Lanes toolbox and provides a walkthrough using the tool interfaces to configure, run, and manage all aspects of the RED Lanes evaluation process.

- Organization of data inputs, configuration information, and outputs simplify the process (see “Data and Workspace Preparation” section above).
- ArcGIS Toolbox designed to facilitate creation and management of hierarchically-related metrics (surfaces).
- See “RED Lanes Evaluation Methodology” document for explanation of measures and general approach.

RED LANES TOOLBOX



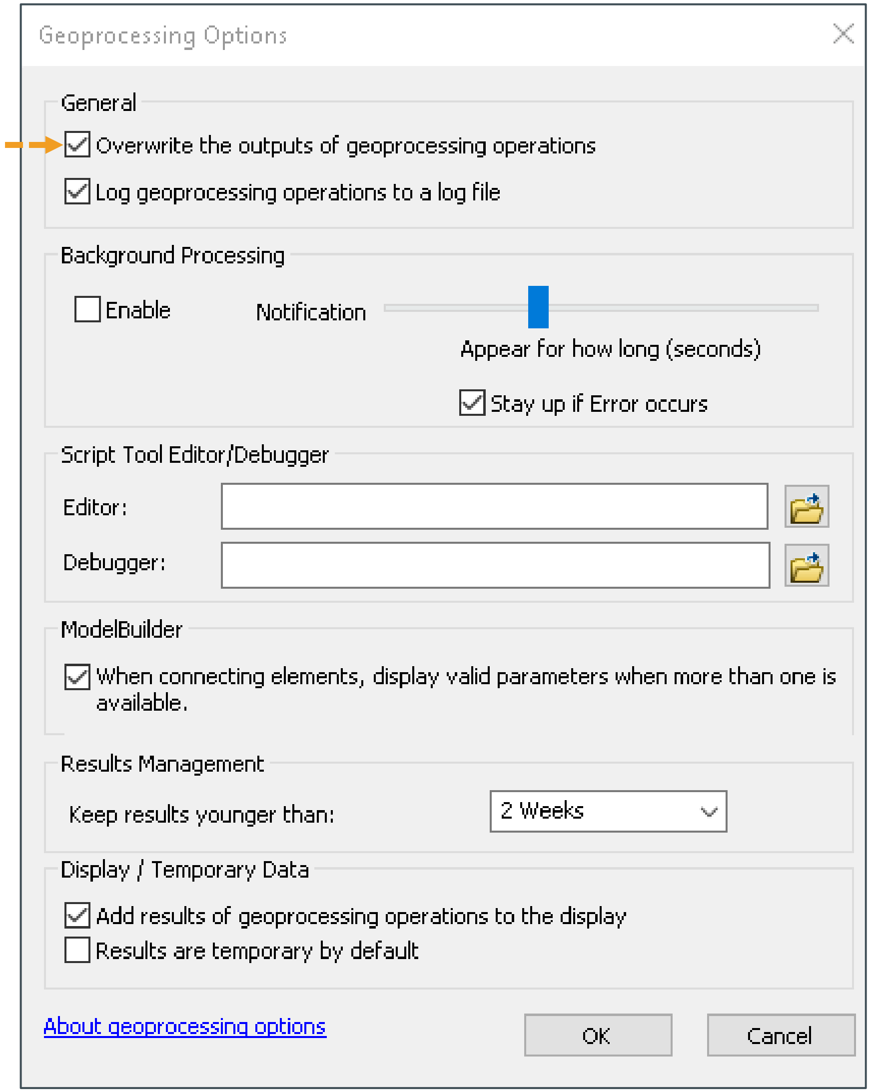
TOOLS

- Create surface object configuration files (.json format)
  - Simple surface
  - Factor
  - Dominant Factor
  - Linear Sum Factor
  - Weighted Overlay
  - Combination
- Copy a directory of configuration files*
- Update the root directory when moving an entire set of configuration files and input data to a new location*
- “Run surface analysis” – using a specified configuration file, create a raster output based on the chosen surface and all prerequisite surfaces

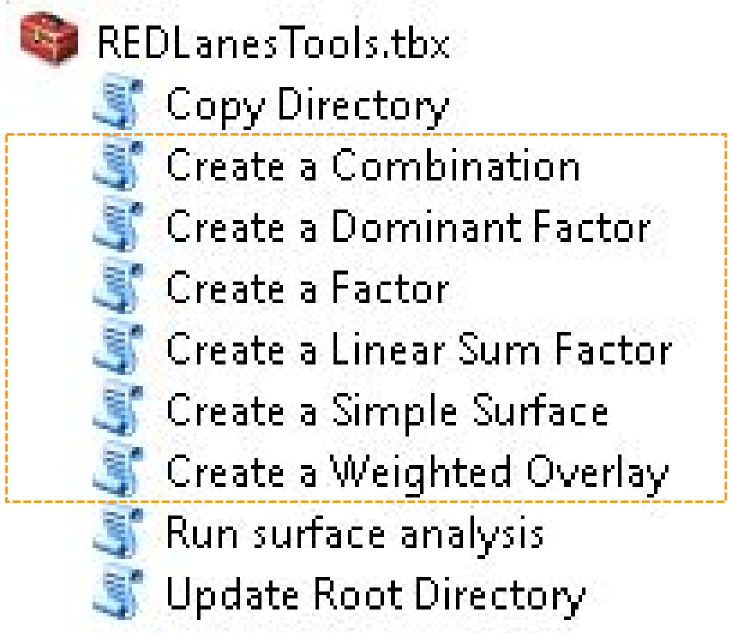
**See “Managing and Sharing Workspaces” in the previous section for more information on the use of each tool.*

RED LANES TOOLBOX – TIPS

- You may need to run ArcGIS as Administrator or work on a local drive rather than a network drive since many of the tools require read/write permissions.
- The tools that create surface object configuration files work best when the option to overwrite geoprocessing outputs is enabled.
  - In ArcMap, the “Geoprocessing Options” dialog can be found in the main window’s menu bar under “Geoprocessing” >> “Geoprocessing Options…”



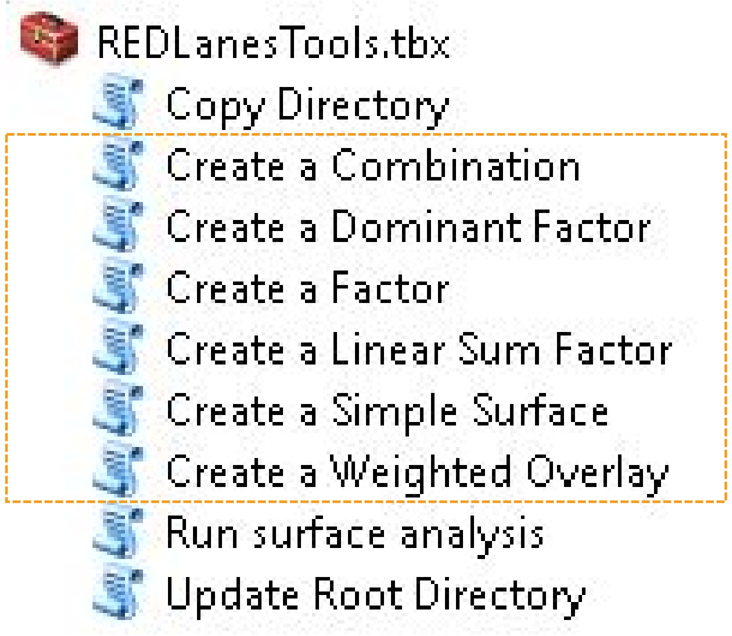
RED LANES TOOLBOX – SURFACE TYPES



TOOLS

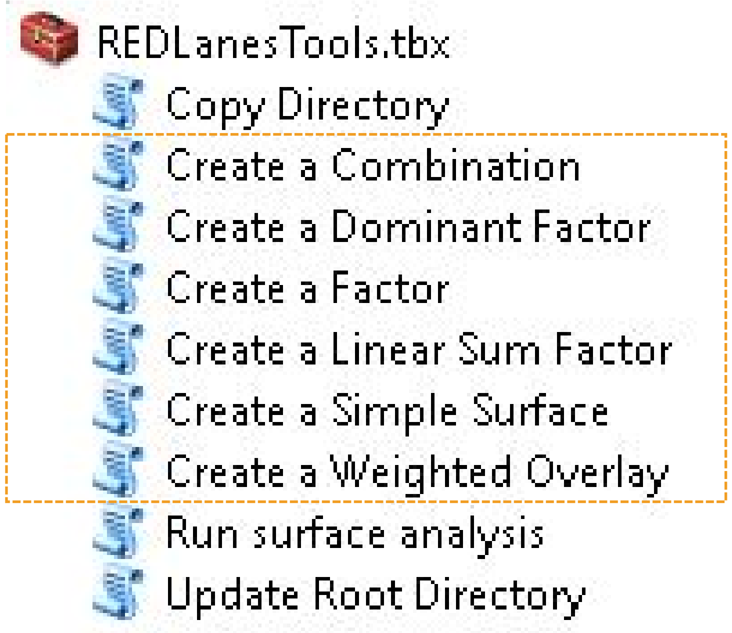
- Different “surface” types:
  - **Simple surface** – Uses an existing raster
  - **Factor** – simple rasterization of vector data
    - **Dominant Factor** – Uses grouping and weight fields to generate a raster containing the indices of the dominant group
    - **Linear Sum Factor** – Simple summation of attribute values of linear features.
  - **Weighted overlay** – weighted averaging of overlapping surface values.
  - **Combination** – combine overlapping surface values to calculate a new value.
- See “PYTHON TOOLKIT DOCUMENTATION” section for details of each surface type.

COMMON ELEMENTS OF SURFACE CREATION



- Details of objects are stored in .json files ("JSON file" field in script tool dialogs) for easy updates and processing
- Description field offers an opportunity to give the surface object a brief description that might be easier to understand than the .json name itself
- "Remap groups" can be specified to automate reclassification of resulting rasters as needed.
  - See RED Lanes Evaluation Methodology Report for threshold details
  - See "PYTHON TOOLKIT DOCUMENTATION" section for illustrations of raster reclassification

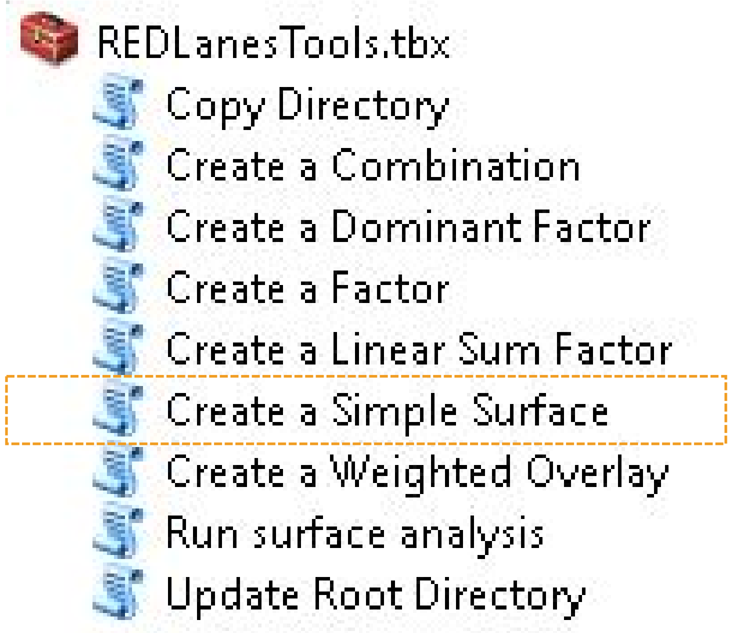
COMMON ELEMENTS OF SURFACE CREATION



- "No data value" specifies how to reclassify any parts of the resulting raster that are missing data (see "PYTHON TOOLKIT DOCUMENTATION" section).
  - For many factors, the No Data Value will be set to 0 or 1, indicating that if no data are present in the resulting raster, there is no suitability or very low suitability.
  - For adjustments, the No Data Value will generally be set to 0 (zero), indicating that no adjustment should be made in areas where no data are present in the resulting raster
- "Keep unmapped values" specifies what to do with values that fall outside the ranges specified in the remap groups. (Note: It is rare to leave any unclassified values, so usually this option has no bearing on the output raster.)
  - If True, unmapped values will be retained during reclassification
  - If False, unmapped values will be converted to "NO DATA" during reclassification and reclassified based on the No Data Value.

SIMPLE SURFACE INPUTS

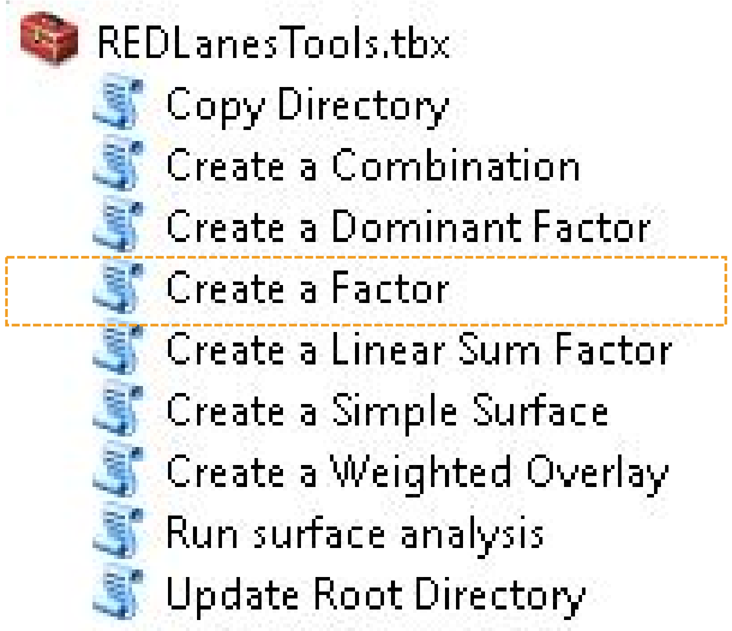
Simple surfaces record the location of existing raster data for use in downstream analyses (see "PYTHON TOOLKIT DOCUMENTATION" section).



- Raster – the path to an existing raster dataset

FACTOR INPUTS

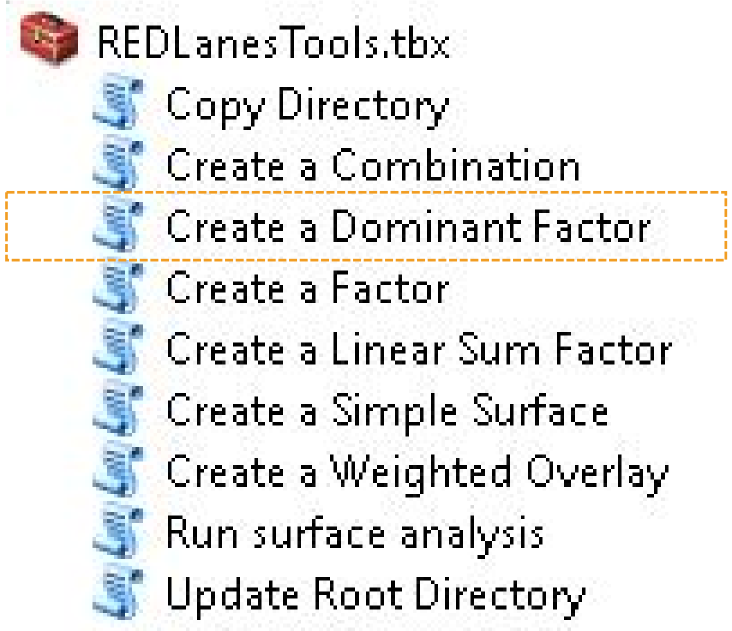
Factors convert vector data to raster data (see “PYTHON TOOLKIT DOCUMENTATION” section)



- Reference feature class – the vector features to convert to a raster dataset
- Weight field – the field in the reference feature class to reference to “weight” the resulting raster dataset (optional depending on “Analysis method”)
- Where clause – sets criteria for which features in the reference feature class to utilize or ignore when converting to a raster dataset
- Analysis method – the measure (sum, mean, count, e.g.) to report in the resulting raster dataset
- Cell size – the size of the cells in the resulting raster dataset (in units equal to the linear units used by the reference feature class’s spatial reference system)
- Neighborhood size – the radius of the floating zone used to analyze the features in the reference feature class to convert to a raster dataset (in units equal to the linear units used by the reference feature class’s spatial reference system)
- Output units – for certain analysis methods, it is possible to specify what units the resulting raster values will be in. Remap values should reflect the chosen output units.

DOMINANT FACTOR INPUTS

Dominant Factors use grouping and weight fields to generate a raster containing the indices of the dominant (or least dominant) group (see “PYTHON TOOLKIT DOCUMENTATION” section)

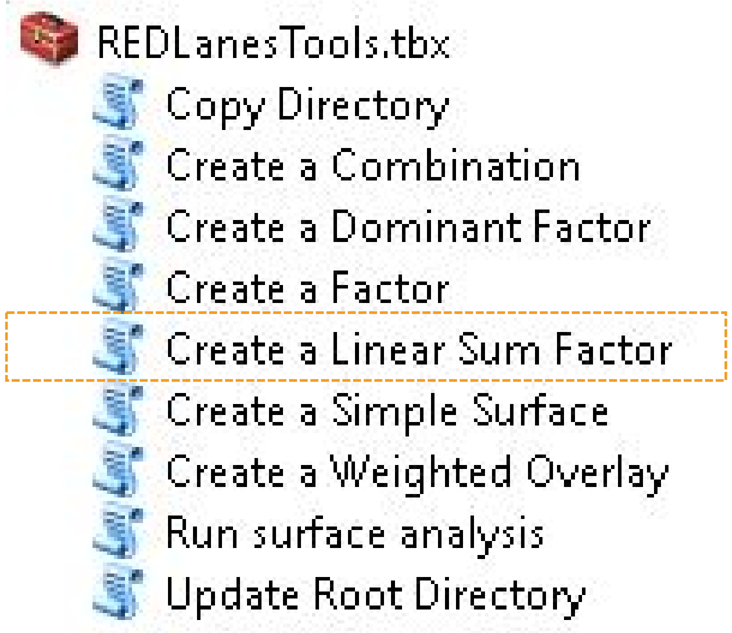


Input fields match those of “Factor” except as noted below.

- <u>Value field</u> – the field in the reference feature class by which to weight features in the rasterization process. Feature weights are summarized for each distinct value in the “group field” and the group with the highest weighted total is identified by its index in the output raster dataset.
- <u>Group field</u> – A field that groups features into distinct categories. When analyzed, the dominant factor will generate a raster with the index value of the “group” with the greatest sum of feature values (provided in the “Value field” in each cell.
- <u>Inverse</u> – If checked, return the raster index of the group with the lowest total feature values in each cell rather than the highest value. If multiple groups are missing (meaning more than one “lowest” group exists), the first index among lowest groups is returned in the raster.

LINEAR SUM FACTOR INPUTS

Linear Sum Factors provide simple summation of attribute values of linear features instead of length-weighted sums. (see "PYTHON TOOLKIT DOCUMENTATION" section)

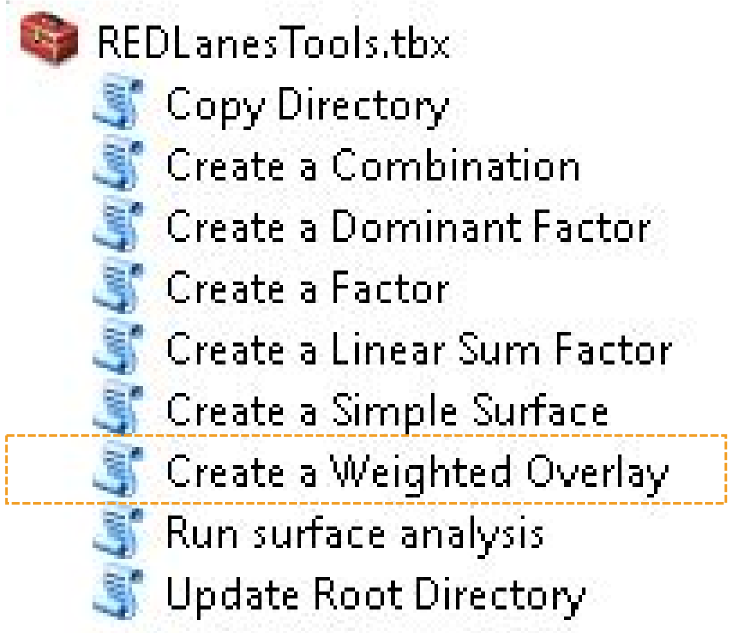


Input fields match those of "Factor" except as noted below.

- ID field – the field in the reference feature class that uniquely identifies each line. This field is required to incorporate a reliable count of line features in the neighborhood.

WEIGHTED OVERLAY INPUTS

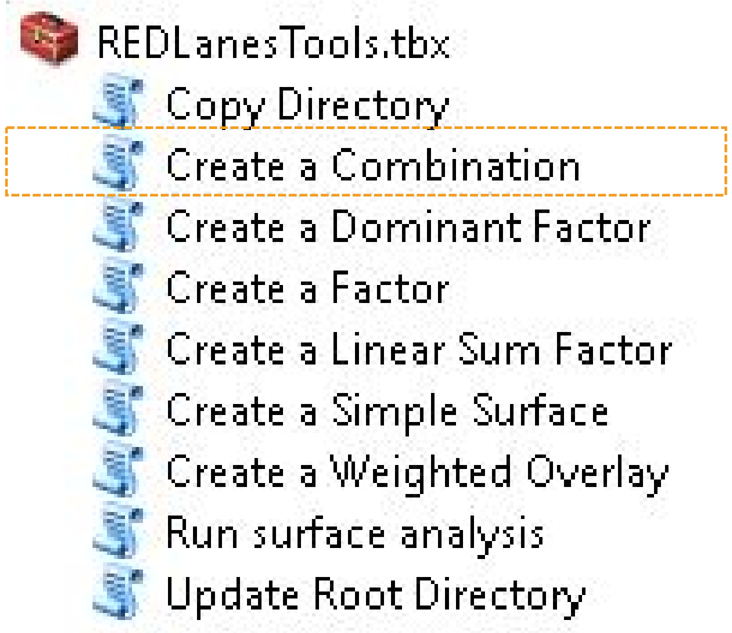
Overlays create a new surface by overlaying two or more existing surface objects (see "PYTHON TOOLKIT DOCUMENTATION" section)



- <u>Input surface json files</u> – list of the json files defining the surfaces to be overlaid to create the resulting raster.
- <u>Weights</u> – the relative weight of each input surface in the resulting raster. The list of weights parallels the list of input json files, so attention must be paid to the order of items in each list.
  - Best practice: the sum of the weights should add to 100.
- <u>Results mapped from/to/by</u> – these parameters define the evaluation scale of the resulting raster to be produced by the overlay. Generally, for the RED Lanes Suitability toolkit, the default values should be used:
  - From: 0
  - To: 10
  - By: 1

COMBINATION INPUTS

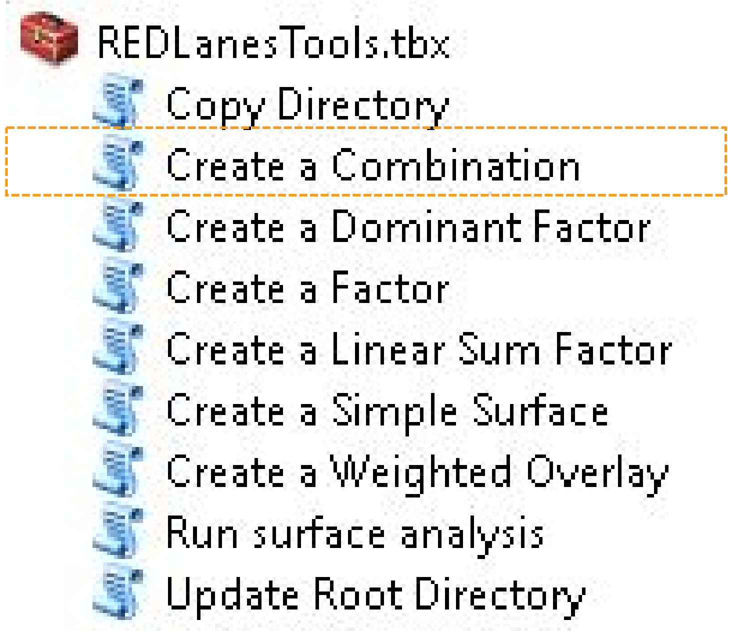
Combinations create a new surface by combining a base surface with one or more adjustment surfaces (see “PYTHON TOOLKIT DOCUMENTATION” section)



- Base surface – the combination will modify the data in this surface’s output raster based on the values in the adjustment surface rasters, combination type, and processing parameters.
- Adjustment surfaces – The raster data to combine with the base surface to produce modified values. Multiple adjustment surfaces can be listed.

COMBINATION INPUTS

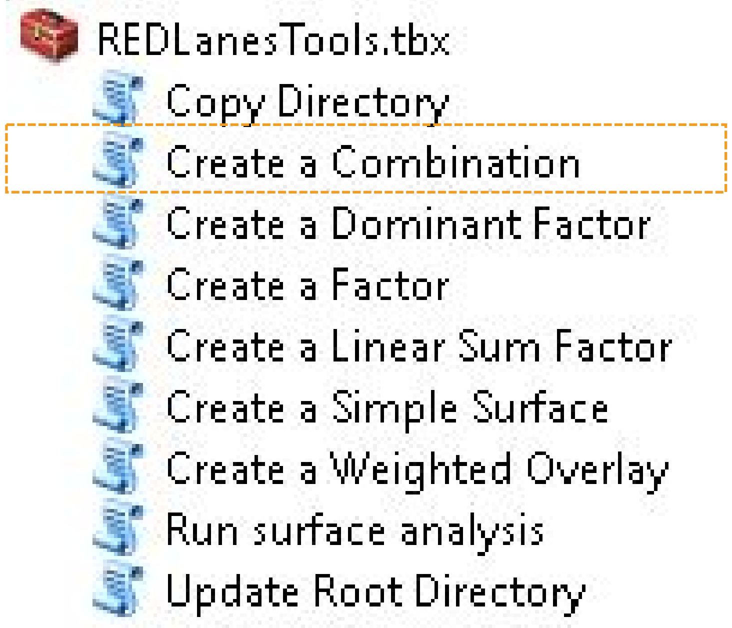
Combinations create a new surface by combining a base surface with one or more adjustment surfaces (see "PYTHON TOOLKIT DOCUMENTATION" section)



- <u>Apply limits/apply above value/apply below value</u> – if the "apply limits" option is selected, only certain values in the base surface will be modified – those above the "apply above value" and those below the "apply below value." All other base surface values will be retained without modification. Not applicable for "lookup" combos.
- <u>Combo type</u> – the modification logic depends on the combination type:
  - Calculation: perform simple mathematical operations to modify the values in the base surface based on values in the adjustment surface(s)
  - Conditional: modify values in the base surface where certain conditions apply in the adjustment surface(s)
  - Lookup: modify values in the base surface based on specific combinations of values with adjustment surfaces as specified in a lookup table.

COMBINATION INPUTS

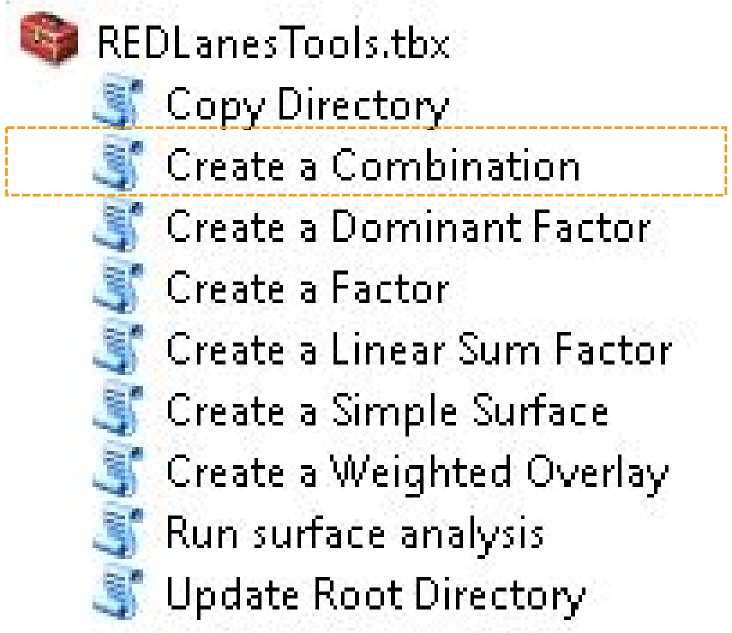
Combinations create a new surface by combining a base surface with one or more adjustment surfaces (see "PYTHON TOOLKIT DOCUMENTATION" section)



- Adjustment surface params – specifications for how to modify the values in the base surface based on the adjustment surface(s). The list of params parallels the list of adjustment factors, so attention must be paid to the order of items in each list. The format of the parameters to enter depend on combo type:
  - Conditional: Comma-separated list as follows: {conditional evaluation}, {value if true}, {value if false}
    - Example: "==1, 801, Base"
    - Interpretation: If the adjustment surface value is equal to 1, alter the base value to be 801, otherwise use the base value
  - Calculation: Comma-separated list as follows: {primary arithmetic operation}, {adjustment factor modification}
    - Example: "+, /3.0"
    - Interpretation: Increase the base surface value by the value in the adjustment surface divided by 3
  - Lookup: The column name in the lookup table that corresponds to the values in the adjustment surface

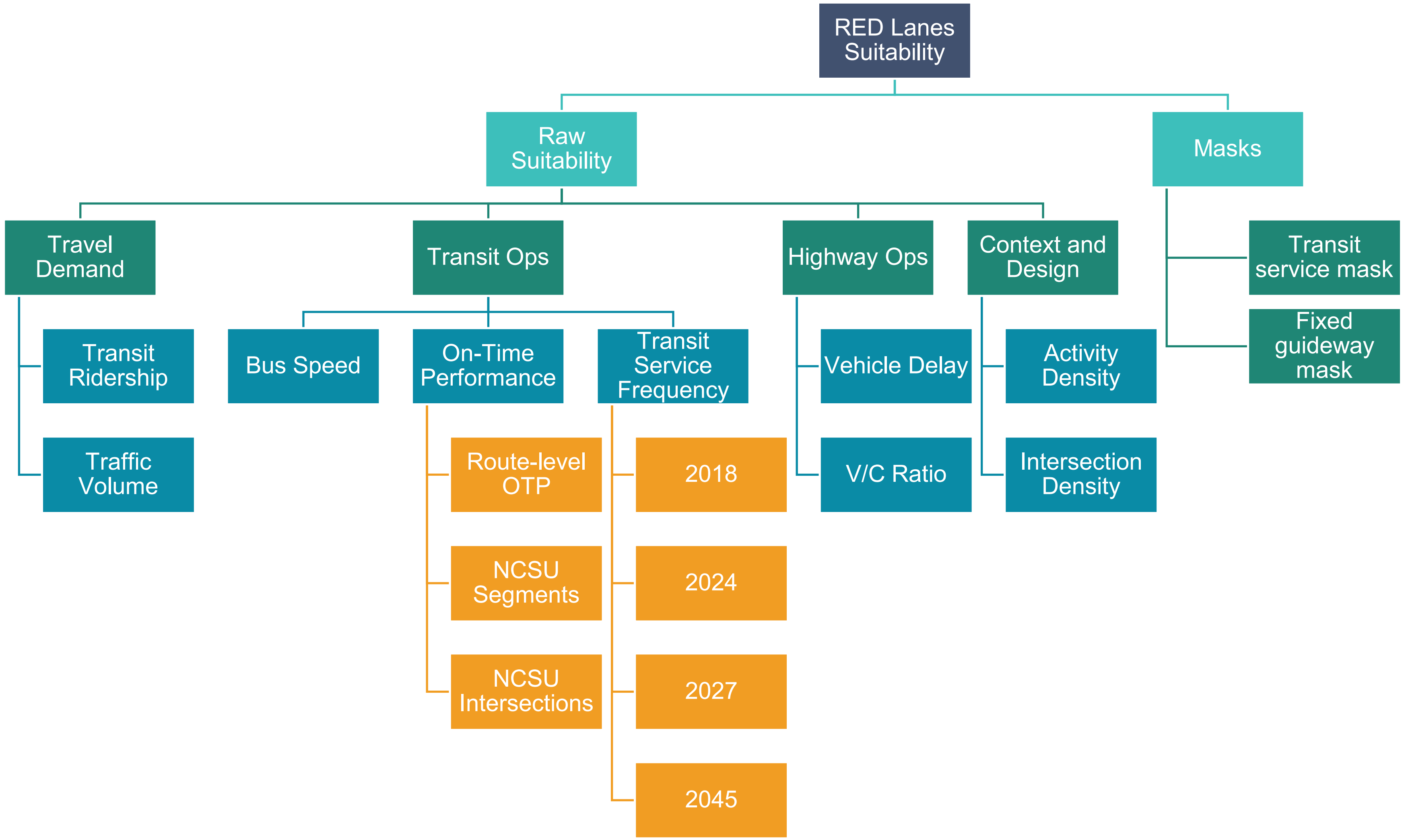
COMBINATION INPUTS

Combinations create a new surface by combining a base surface with one or more adjustment surfaces (see "PYTHON TOOLKIT DOCUMENTATION" section)

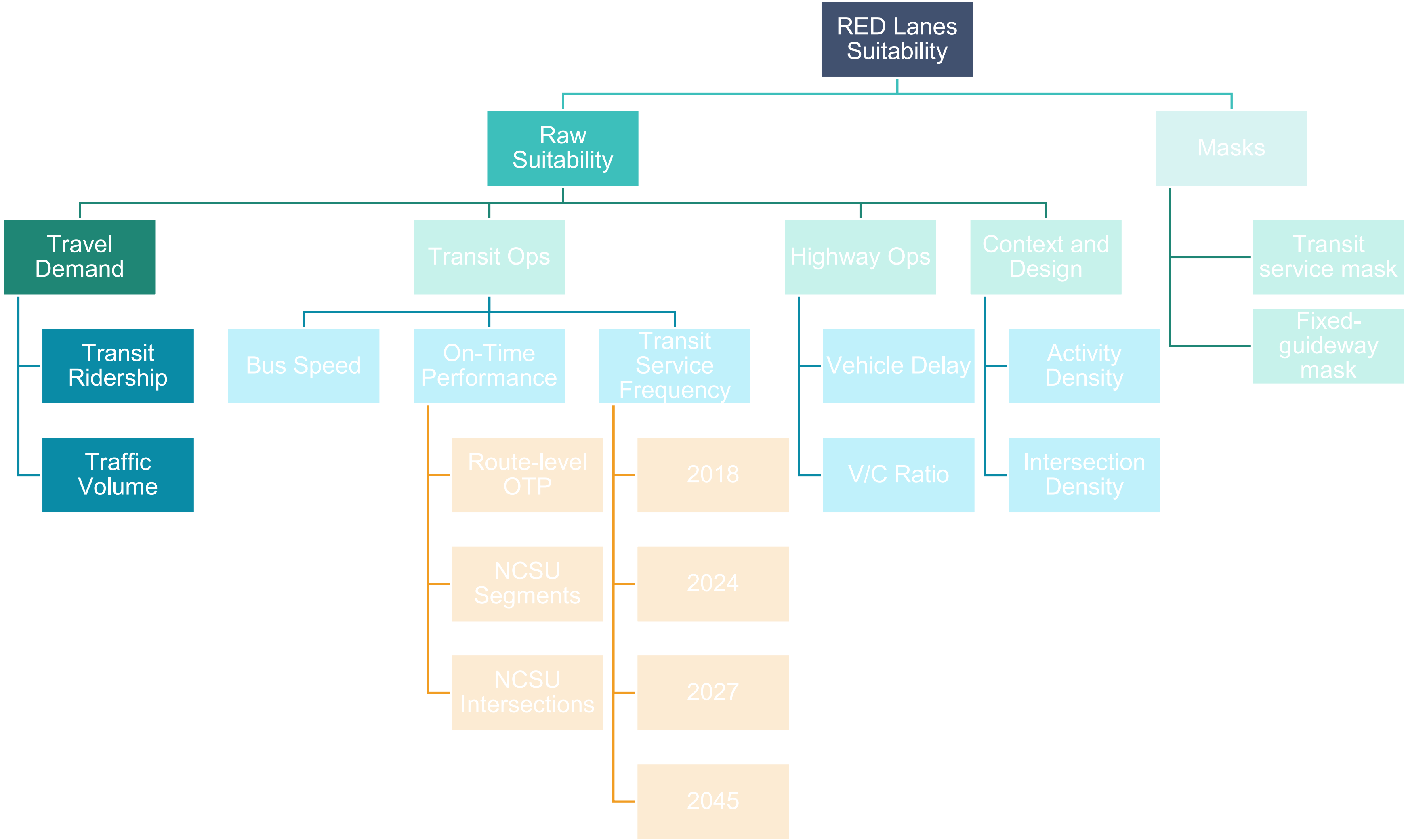


- Apply calculation bounds/Calculation lower bound/Calculation upper bound – if the "apply calculation bounds" option is selected, the results of the calculation will be capped based on the "calculation lower bound" and "calculation upper bound" values. Applicable for "calculation" combinations only.
- Lookup table\Base value column\New value column – The table that defines what values will be yielded by specific combinations of base and adjustment values. The "base value column" refers to values in the base surface. The new value column defines resulting values. Adjustment factor values are looked up from columns as specified in the Adjustment Surfaces Params input. Applicable for "lookup" combos only.

DETAILED IMPLEMENTATION STEPS – RED LANES SUITABILITY



SUITABILITY – TRAVEL DEMAND

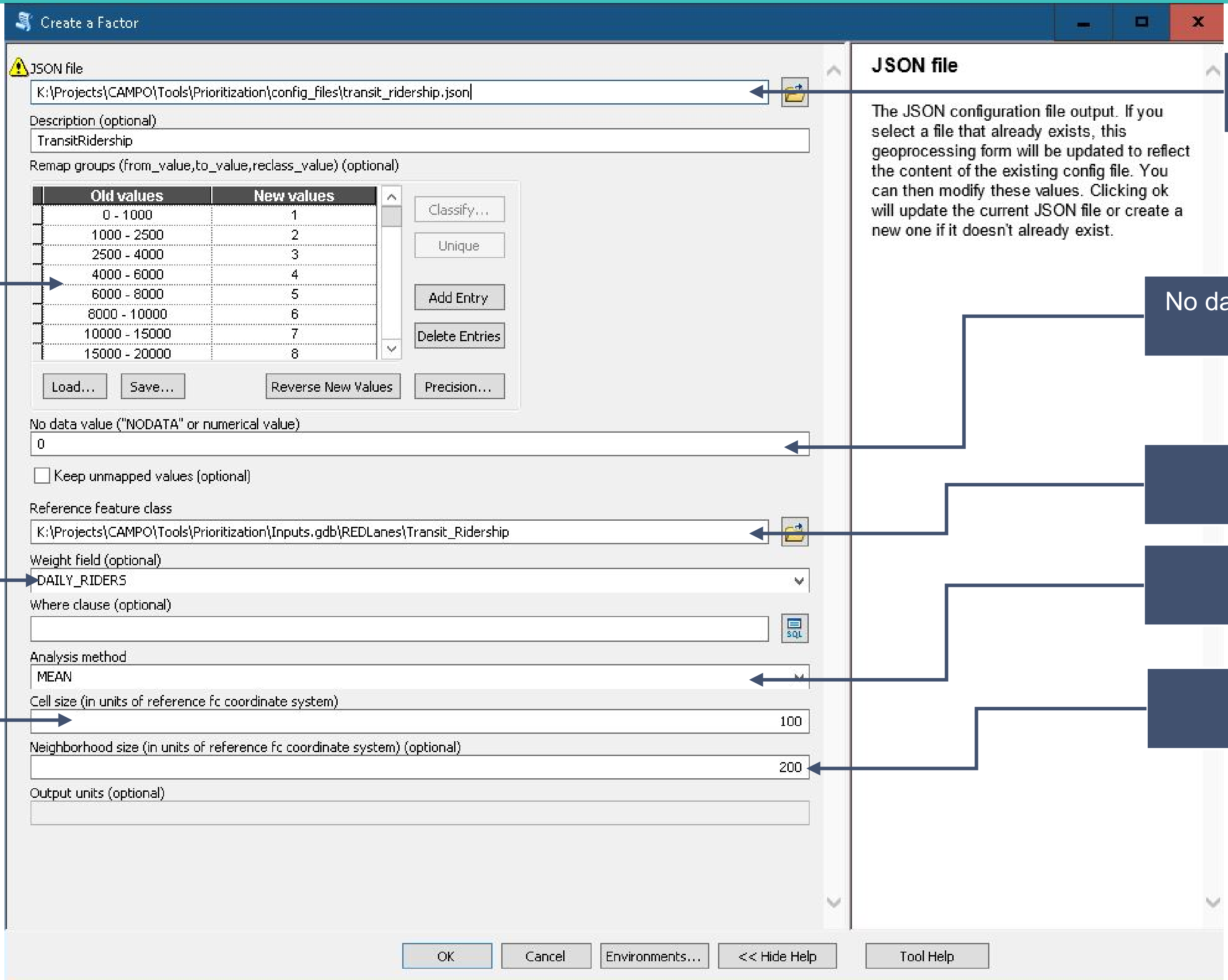


SUITABILITY – TRAVEL DEMAND – TRANSIT RIDERSHIP

Remap groups: load from {remaps_dir}/transit_ridership

Weight field: DAILY_RIDERS

Cell size: 100 (feet)



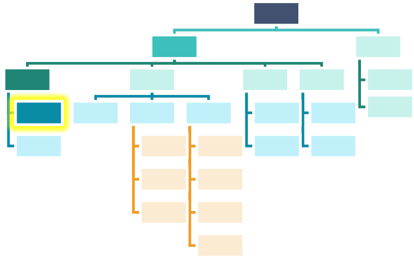
JSON file: {config_dir}\transit_ridership.json

No data value: 0 (No suitability due to ridership if no ridership data in neighborhood)

Reference feature class: {inputs_gdb}\Transit_Ridership

Analysis method: MEAN

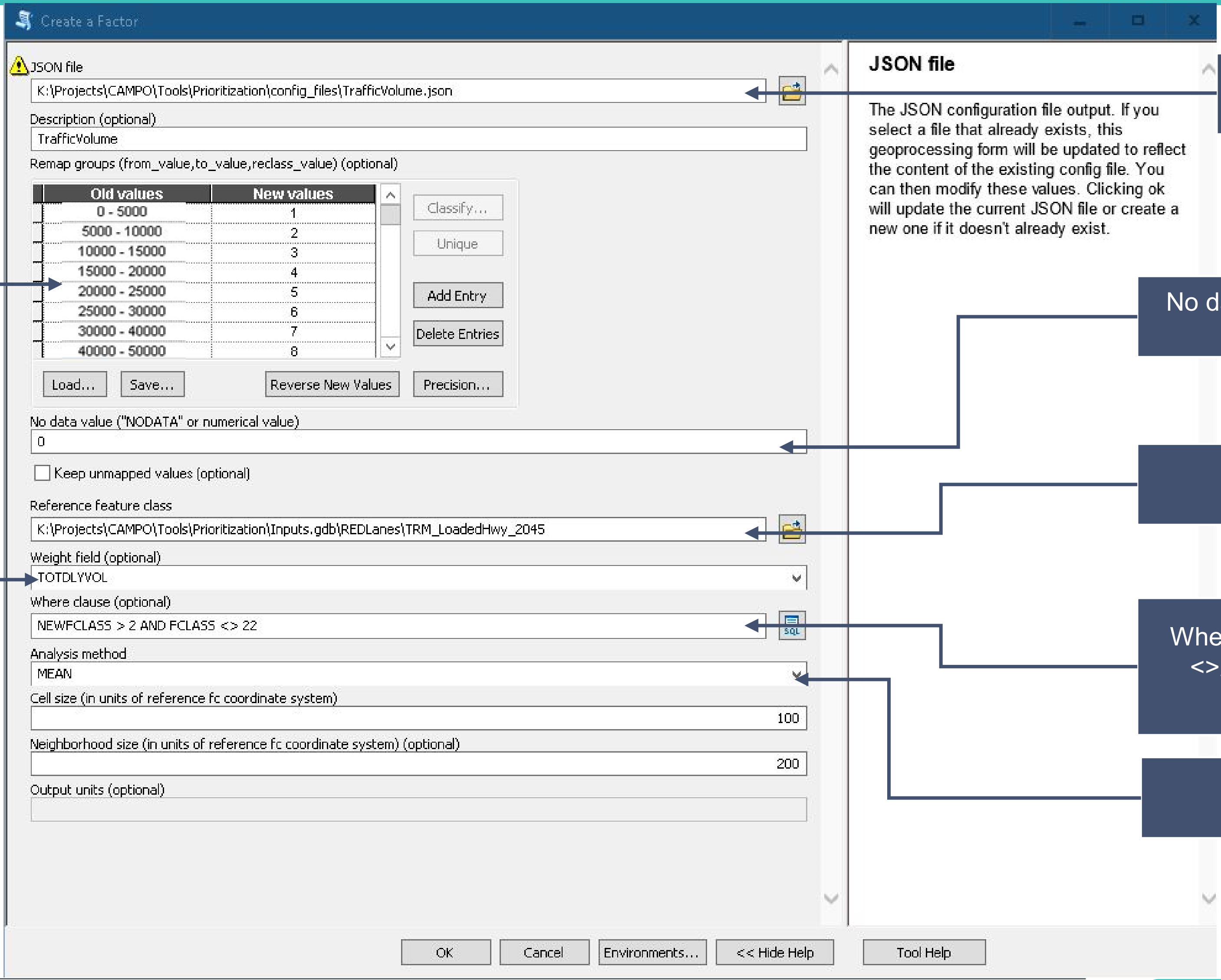
Neighborhood size: 200 (feet)



SUITABILITY – TRAVEL DEMAND – TRAFFIC VOLUME

Remap groups: load from {remaps_dir}/TrafficVolume

Weight field: TOTDLYVOL



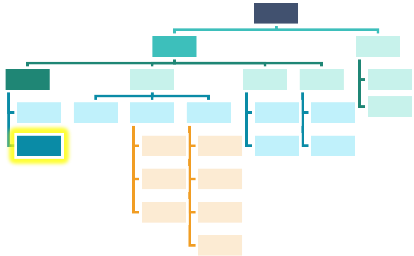
JSON file: {config_dir}\TrafficVolume.json

No data value: 0 (No suitability due to volume if no volume data in neighborhood)

Reference feature class: {inputs_gdb}\TRM_LoadedHwy_2045

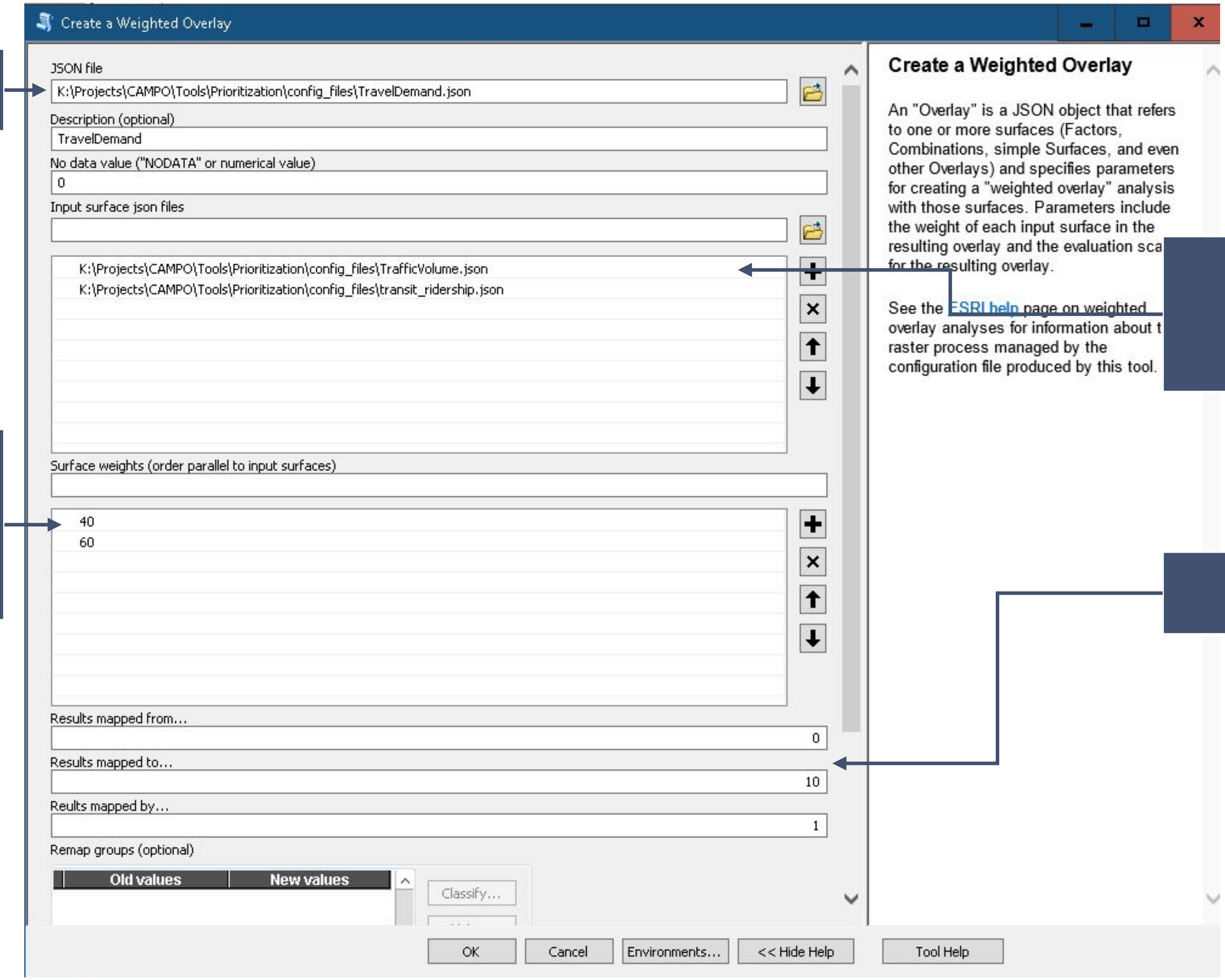
Where clause: NEWFCLASS>2 AND FCLASS <>22 (only include non-limited access/non-tollway facilities)

Analysis method: MEAN



SUITABILITY – TRAVEL DEMAND – OVERLAY

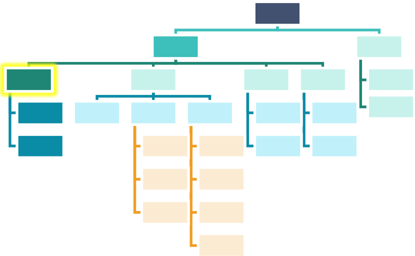
JSON file:
{config_dir}\TravelDemand.json



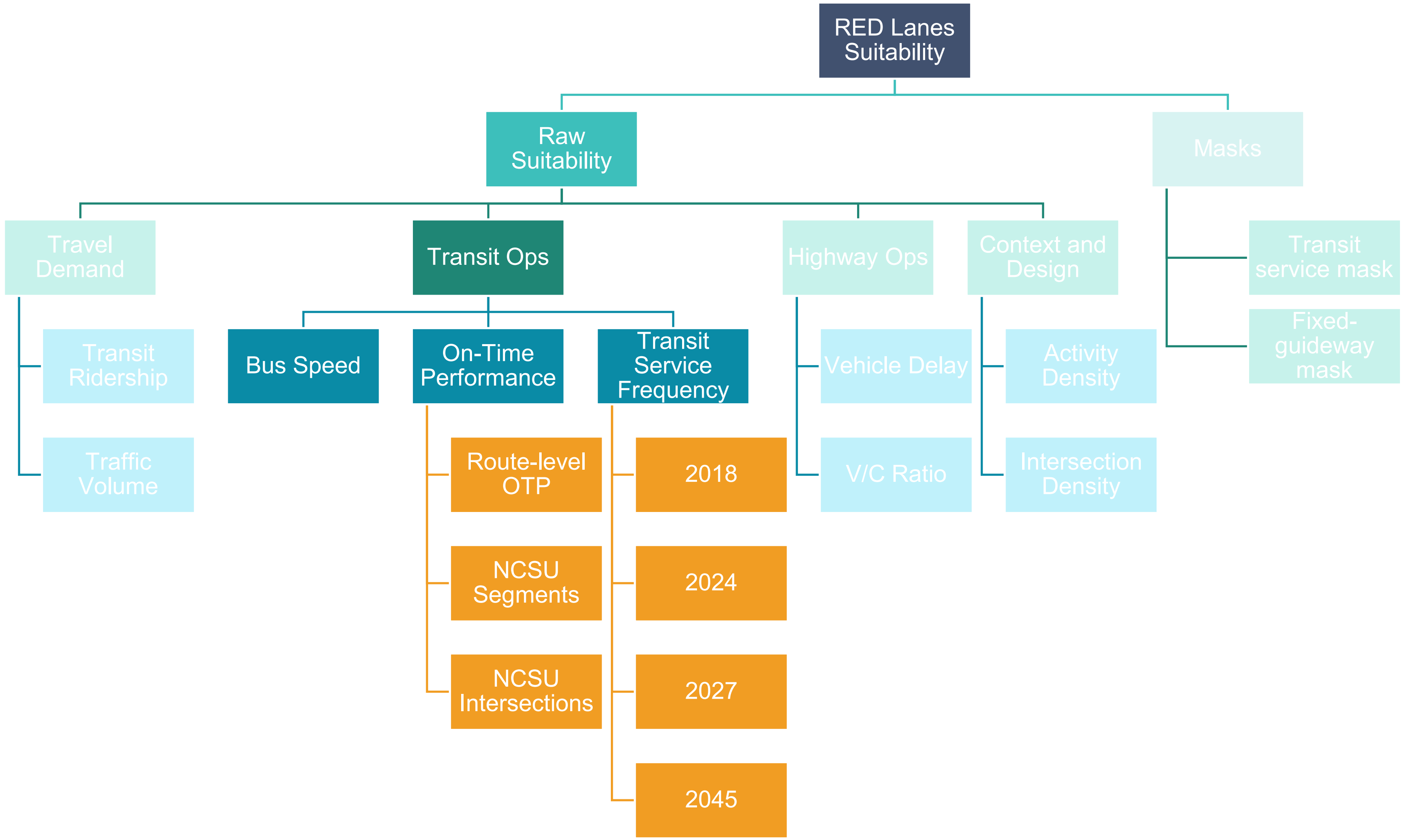
Input surface json files:
{config_dir}\TrafficVolume.json
{config_dir}\transit_ridership.json

Weights:
Traffic volume: 40
Transit ridership: 60

Results mapped from/to/by:
Defaults (0/10/1)



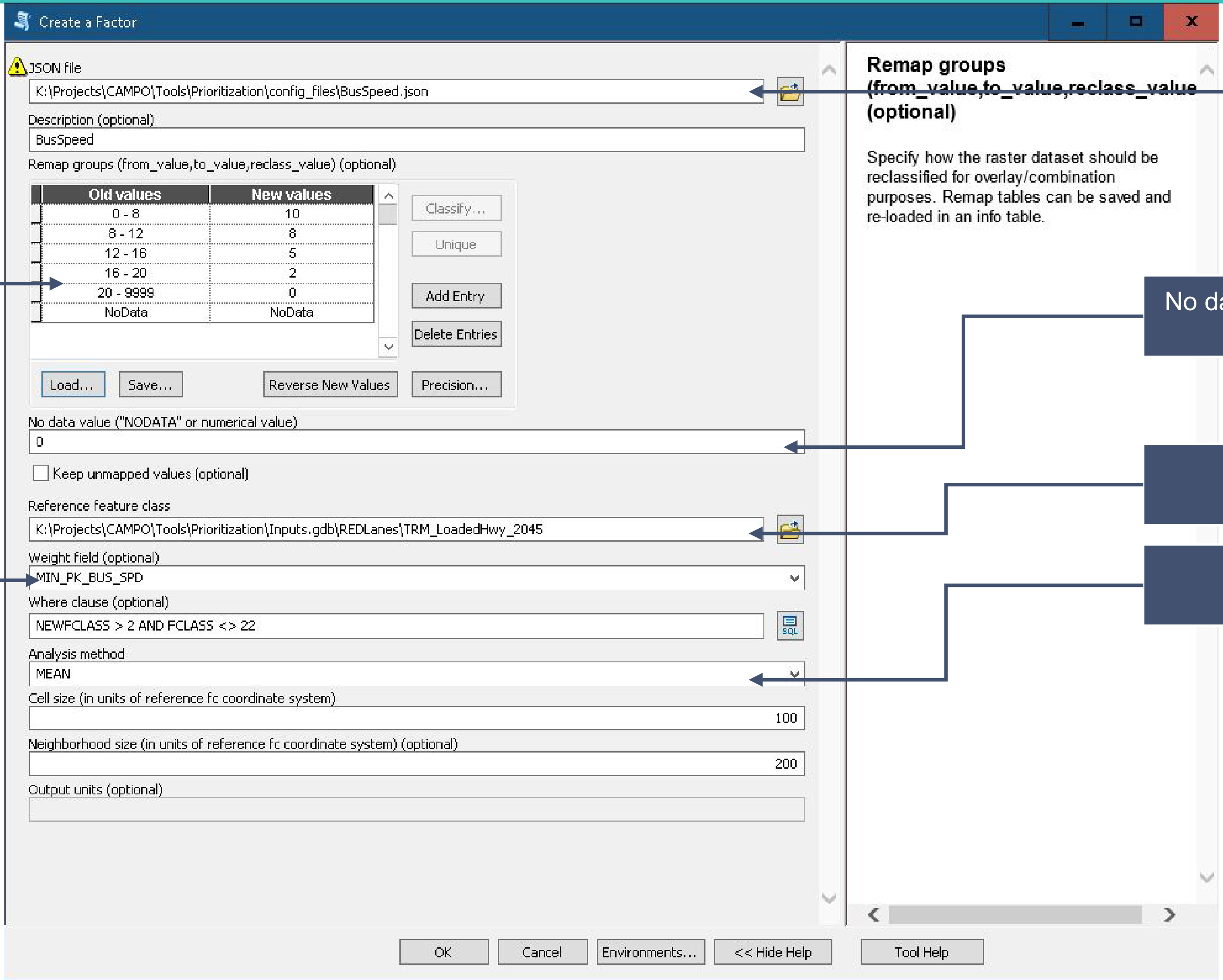
SUITABILITY – TRANSIT OPERATIONS



SUITABILITY – TRANSIT OPS – BUS SPEED

Remap groups: load from {remaps_dir}/BusSpeed

Weight field: MIN_PK_BUS_SPD

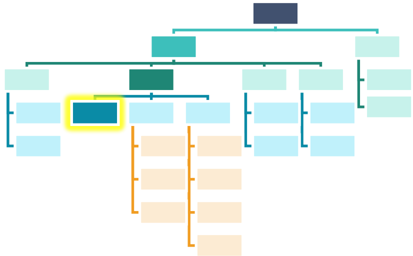


JSON file: {config_dir}\BusSpeed.json

No data value: 0 (No suitability due to bus speed if no bus speed data in neighborhood)

Reference feature class: {inputs_gdb}\TRM_LoadedHwy_2045

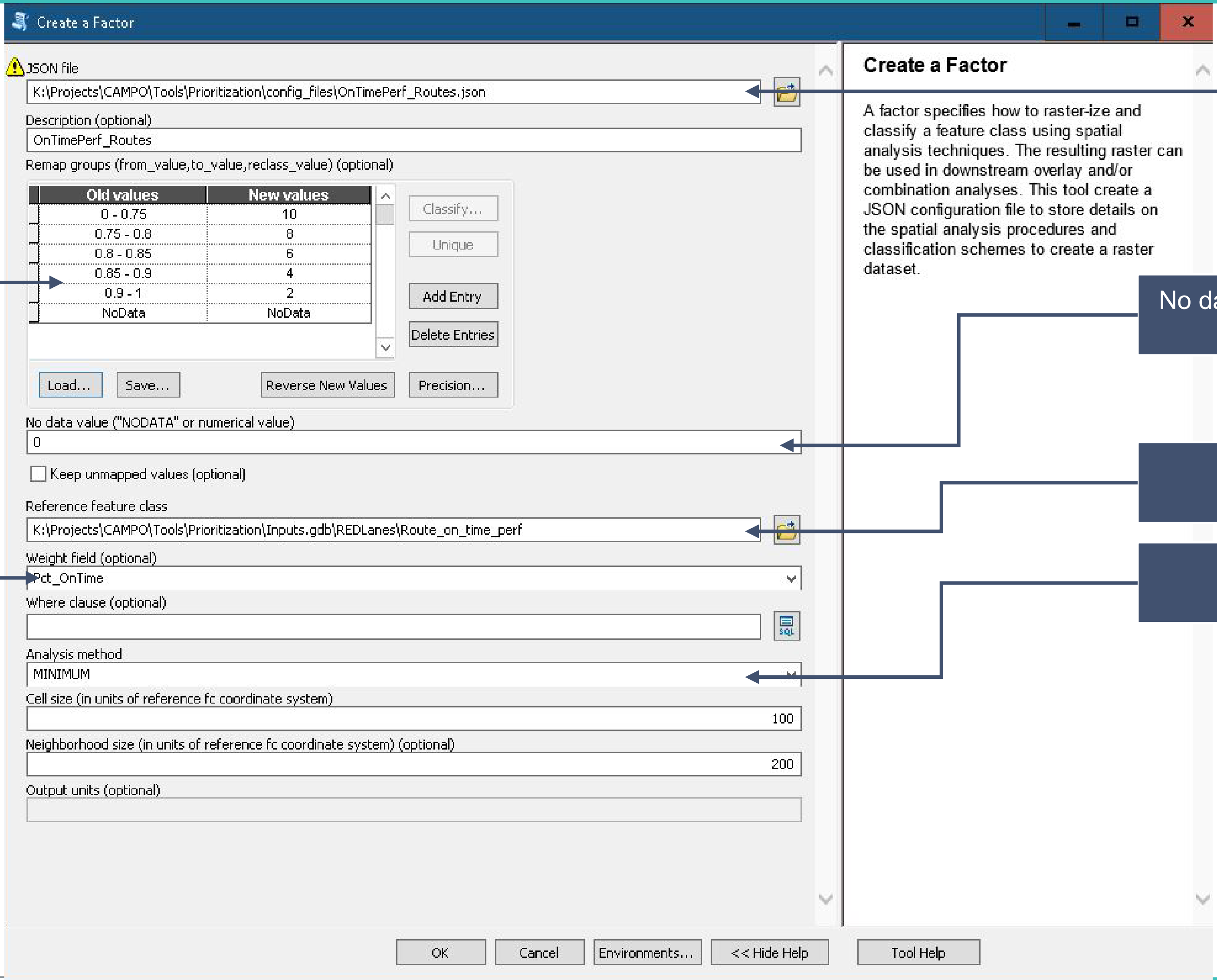
Analysis method: MEAN



SUITABILITY – TRANSIT OPS – ON TIME PERFORMANCE – ROUTES

Remap groups: load from {remaps_dir}/on_time_perf

Weight field: Pct_OnTime

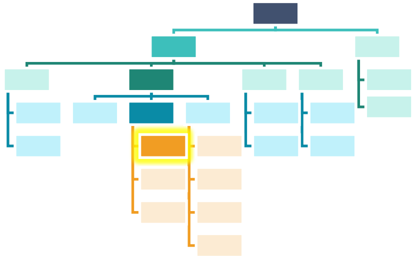


JSON file: {config_dir}\OnTimePerf_Routes.json

No data value: 0 (No suitability due to route OTP if no OTP data in neighborhood)

Reference feature class: {inputs_gdb}\Route_on_time_oerf

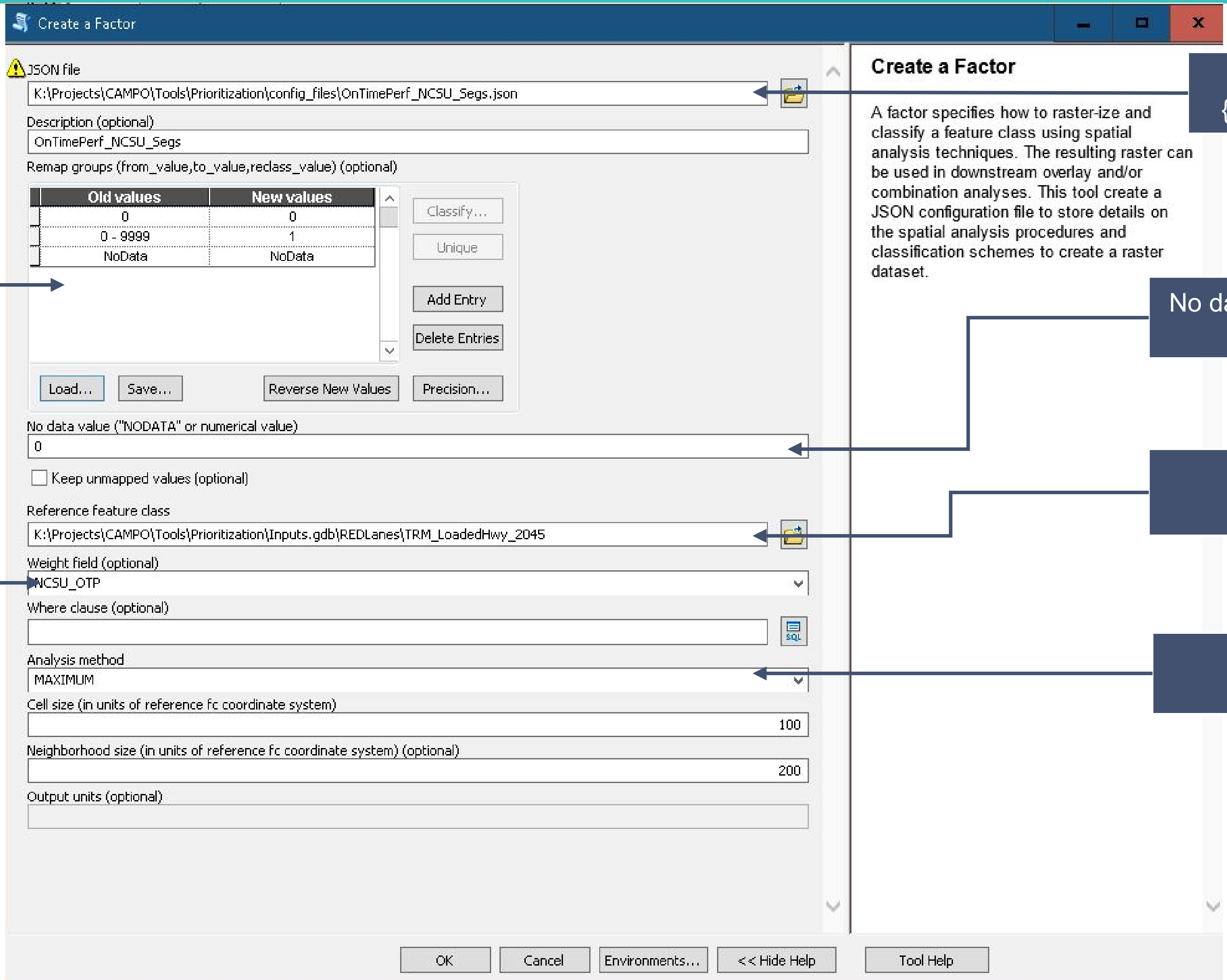
Analysis method: MINIMUM



SUITABILITY – TRANSIT OPS – ON TIME PERFORMANCE – NCSU SEGMENTS

Remap groups: load from {remaps_dir}/ncsu_otp

Weight field: NCSU_OTP (this is not a native TRM field, but a user-added field to flag segments identified by NCSU Wolfline staff as presenting reliability challenges

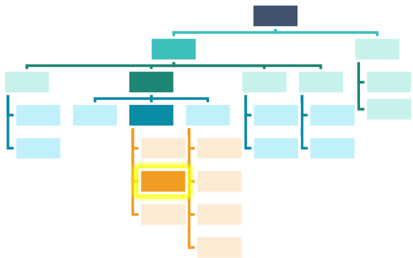


JSON file: {config_dir}\OnTimePerf_NCSU_Segs.json

No data value: 0 (No suitability due to no flagged NCSU segments in neighborhood)

Reference feature class: {inputs_gdb}\TRM_LoadedHwy_2045

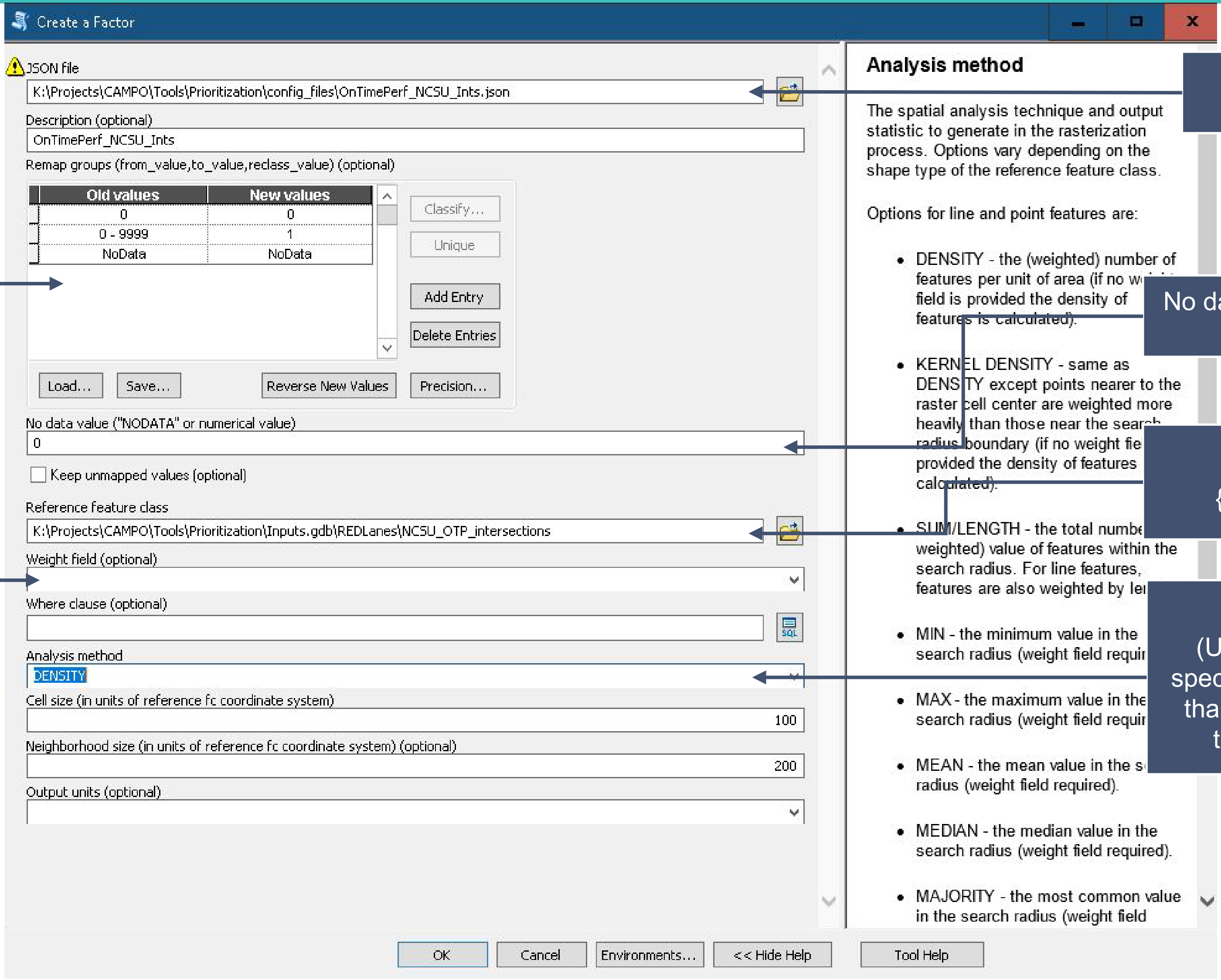
Analysis method: MAXIMUM



SUITABILITY – TRANSIT OPS – ON TIME PERFORMANCE – NCSU INTERSECTIONS

Remap groups: load from {remaps_dir}/ncsu_otp

Weight field: (None)

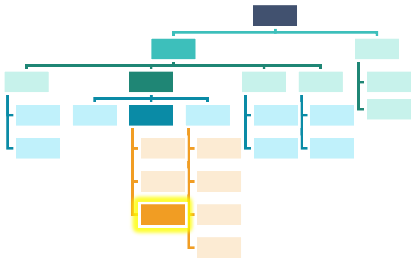


JSON file: {config_dir}\OnTimePerf_NCSU_Ints.json

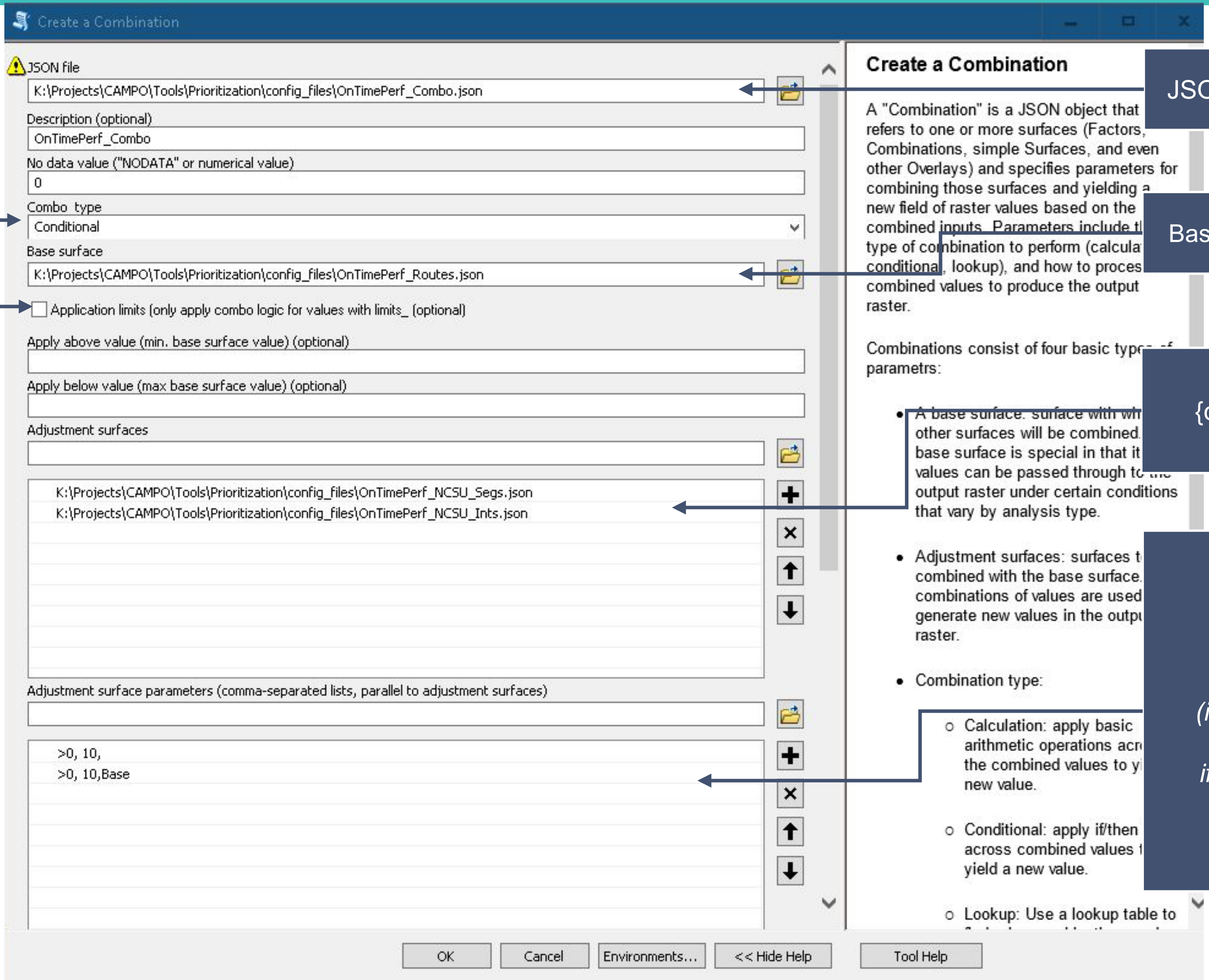
No data value: 0 (No suitability due to no flagged NCSU intersections in neighborhood)

Reference feature class: {inputs_gdb}\NCSU_OTP_intersections

Analysis method: DENSITY (Using this method means we don't have to specify a weight field – feature densities greater than zero are all we need to flag intersections that present transit reliability challenges)



SUITABILITY – TRANSIT OPS – ON TIME PERFORMANCE COMBO



JSON file: {config_dir}\OnTimePerf_Combo.json

Combo type: Conditional

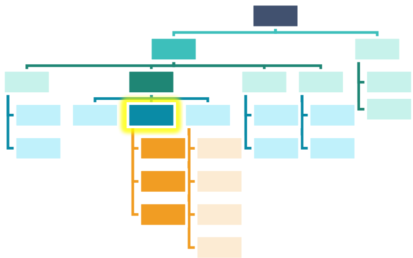
Base factor: {config_dir}\OnTimePerf_Routes.json

Apply limits: False (unchecked)

Adjustment surfaces:
{config_dir}\OnTimePerf_NCSU_Segs.json
{config_dir}\OnTimePerf_NCSU.json

Adjustment surface parameters
>0, 10,
>0, 10, Base

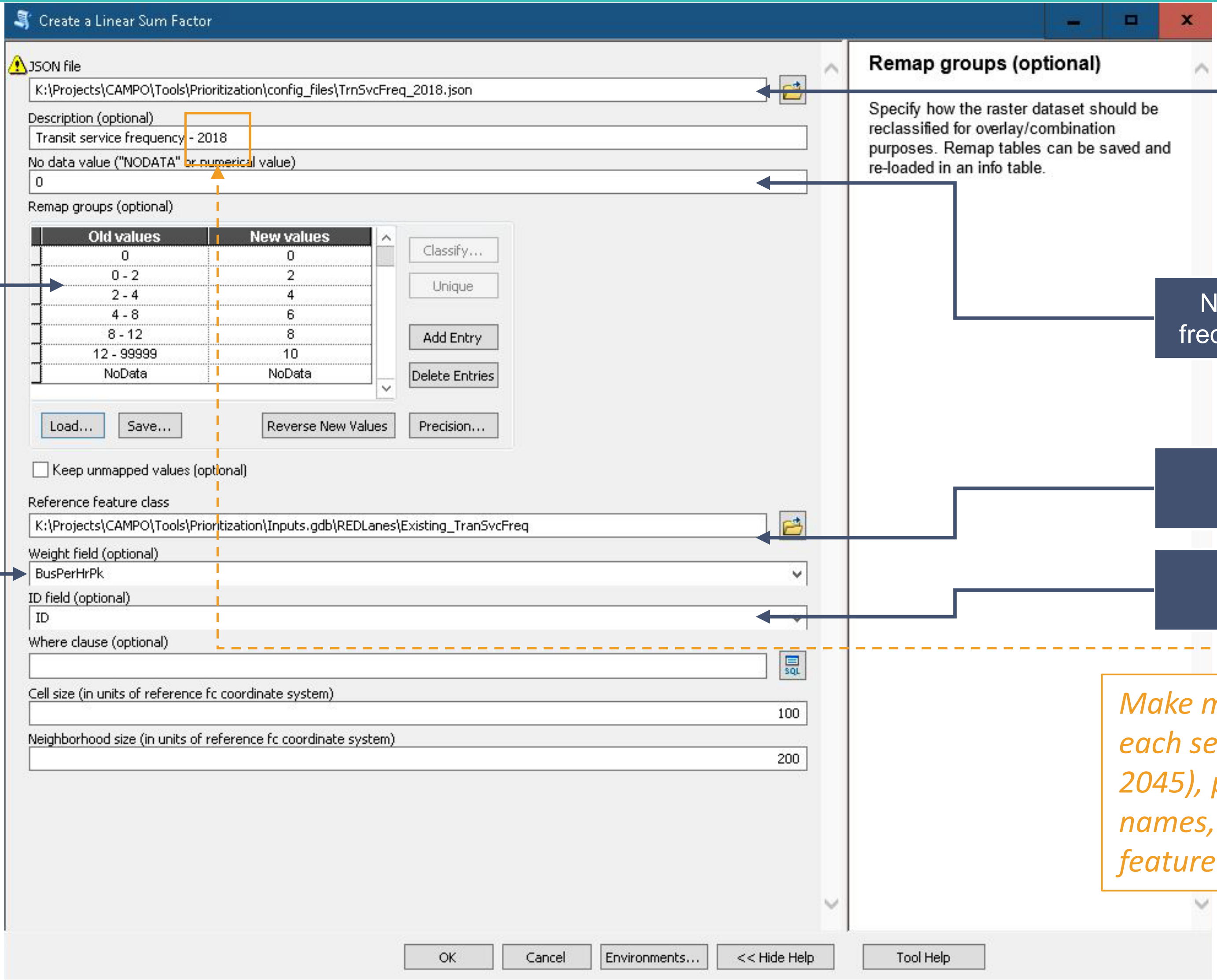
(if OnTimePerf_NCSU_segs > 0, return 10,
else....
if OnTimePerf_NCSU_Intss > 0, return 10,
else....
Return the value in the base surface)



SUITABILITY – TRANSIT OPS – TRANSIT SERVICE FREQUENCY - YEARS

Remap groups: load from {remaps_dir}/transit_service_freq

Weight field: BusPerHrPk



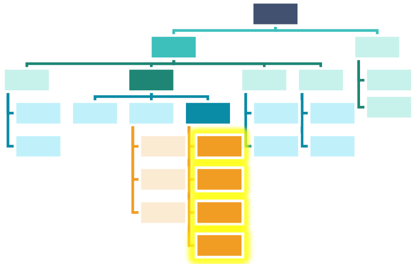
JSON file: {config_dir}\TrnSvcFreq_2018.json

No data value: 0 (No suitability due to transit frequency if no frequency data in neighborhood)

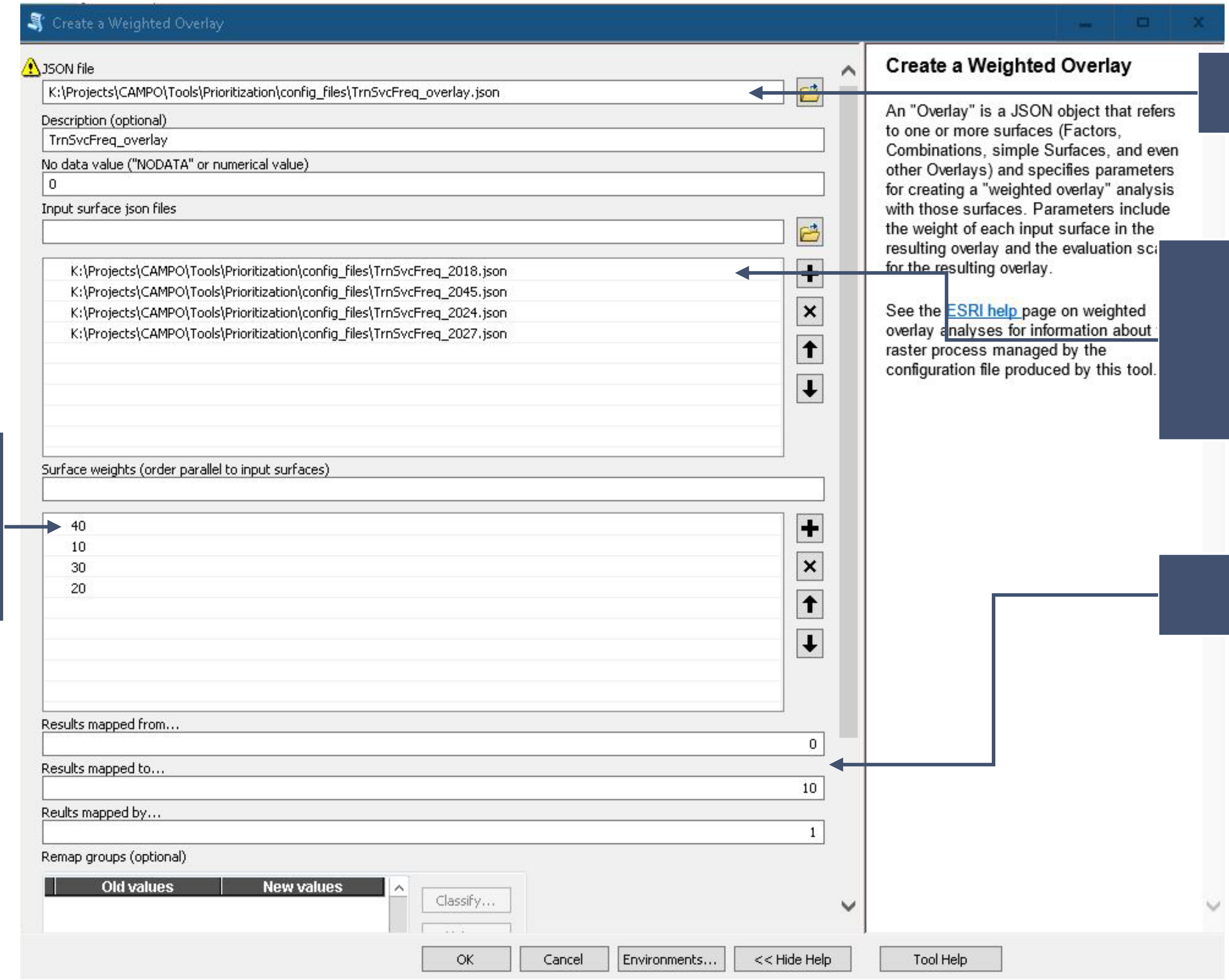
Reference feature class: {inputs_gdb}\Existing_TranSvcFreq

ID Field: ID

Make multiple config files – one for each service year (2018, 2024, 2027, 2045), providing appropriate file names, descriptions, and reference feature classes to the tool.



SUITABILITY – TRANSIT OPS – TRANSIT SERVICE FREQUENCY OVERLAY

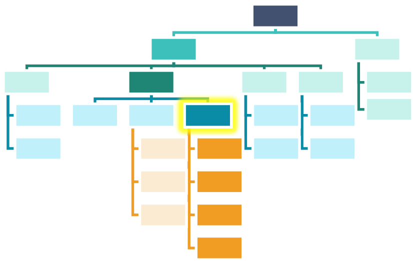


JSON file:
{config_dir}\TrnSvcFreq_overlay.json

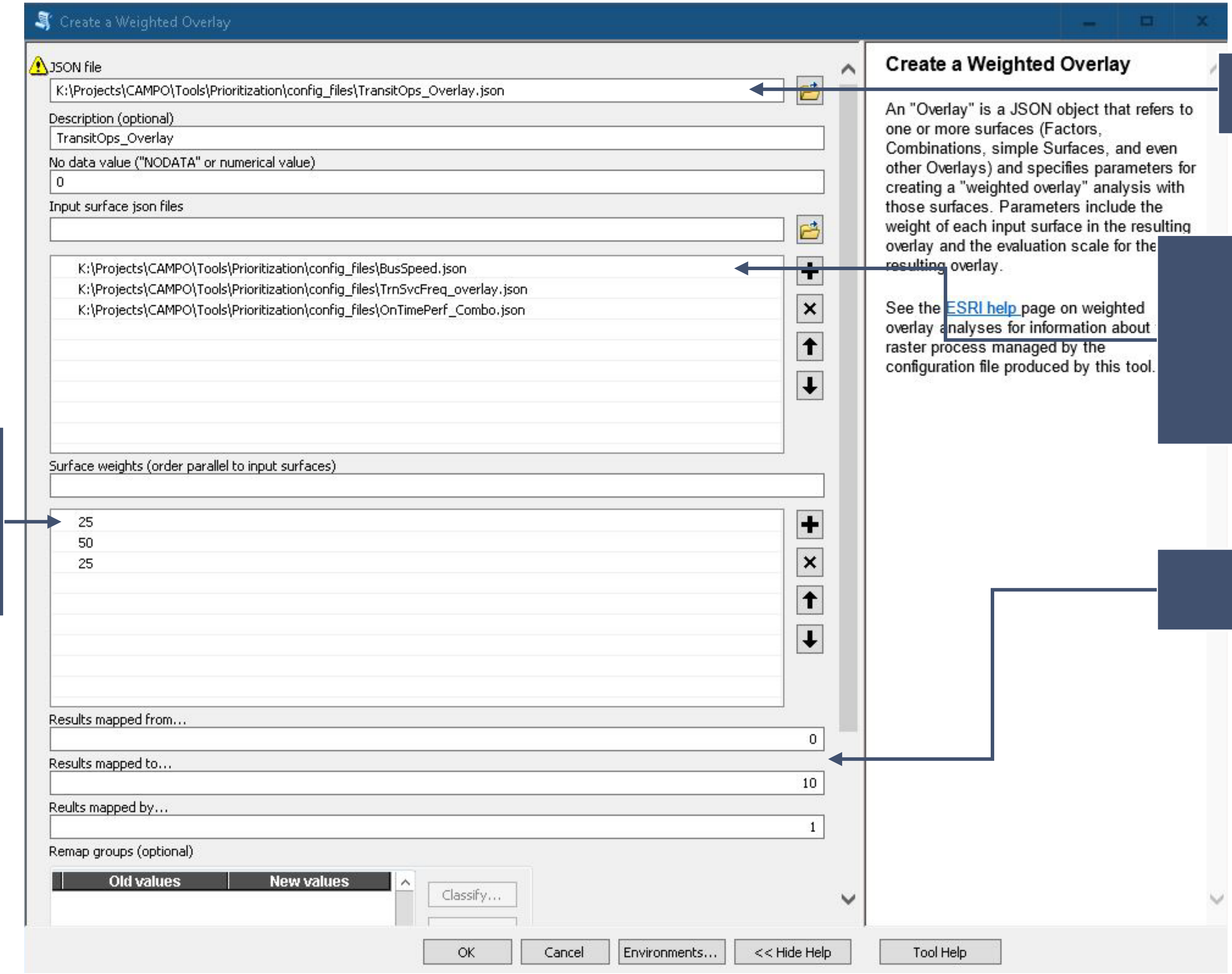
Input surface json files:
{config_dir}\TrnSvcFreq_2018.json
{config_dir}\TrnSvcFreq_2045.json
{config_dir}\TrnSvcFreq_2024.json
{config_dir}\TrnSvcFreq_2027.json

Weights:
2018: 40
2045: 10
2024: 30
2027: 20

Results mapped from/to/by:
Defaults (0/10/1)



SUITABILITY – TRANSIT OPS – OVERLAY

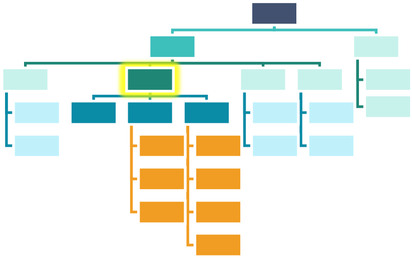


JSON file:
{config_dir}\TransitOps_Overlay.json

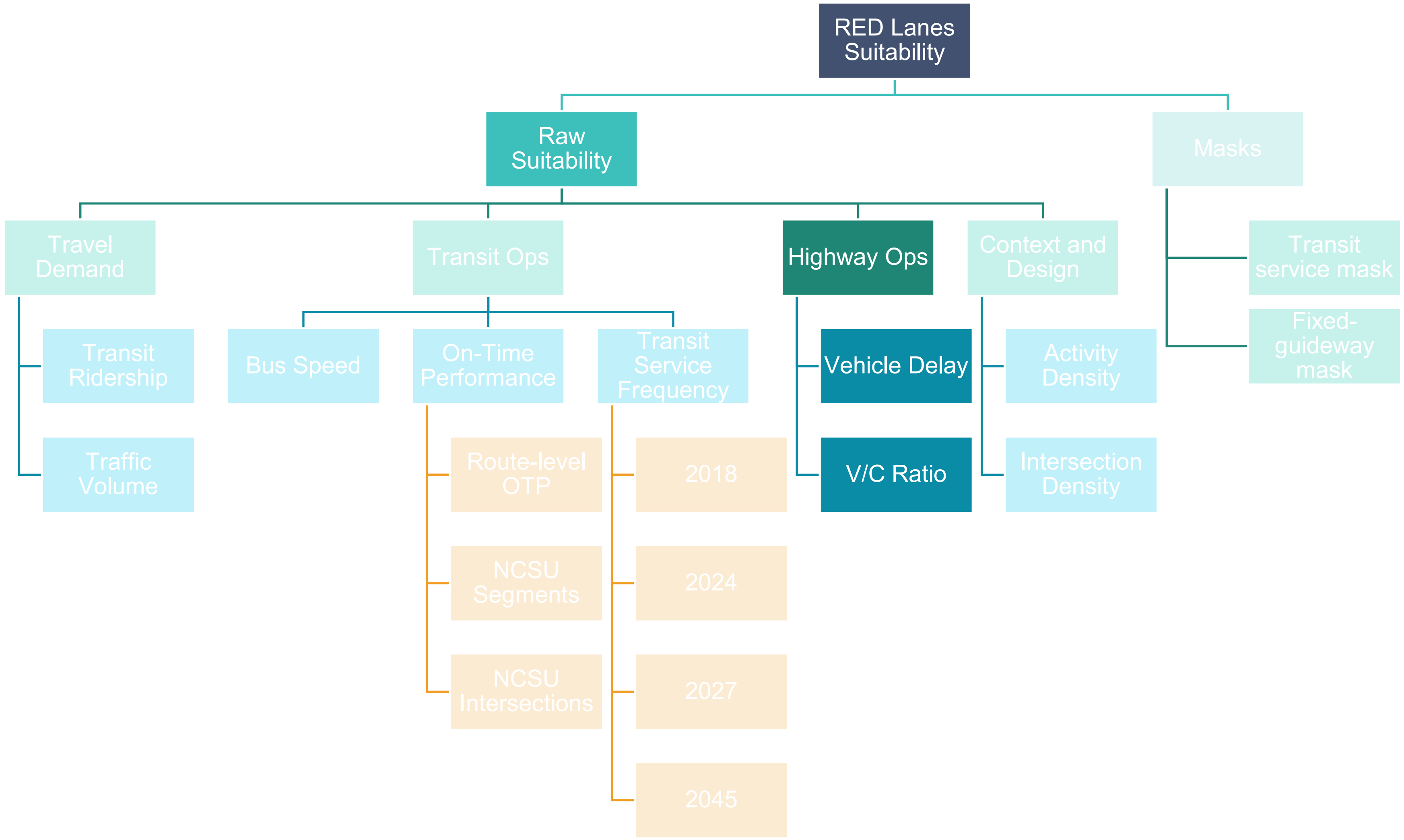
Input surface json files:
{config_dir}\BusSpeed.json
{config_dir}\TrnSvcFreq_overlay.json
{config_dir}\OnTimePerf_Combo.json

Weights:
Bus speed: 25
Transit service frequency: 50
On-time performance: 25

Results mapped from/to/by:
Defaults (0/10/1)



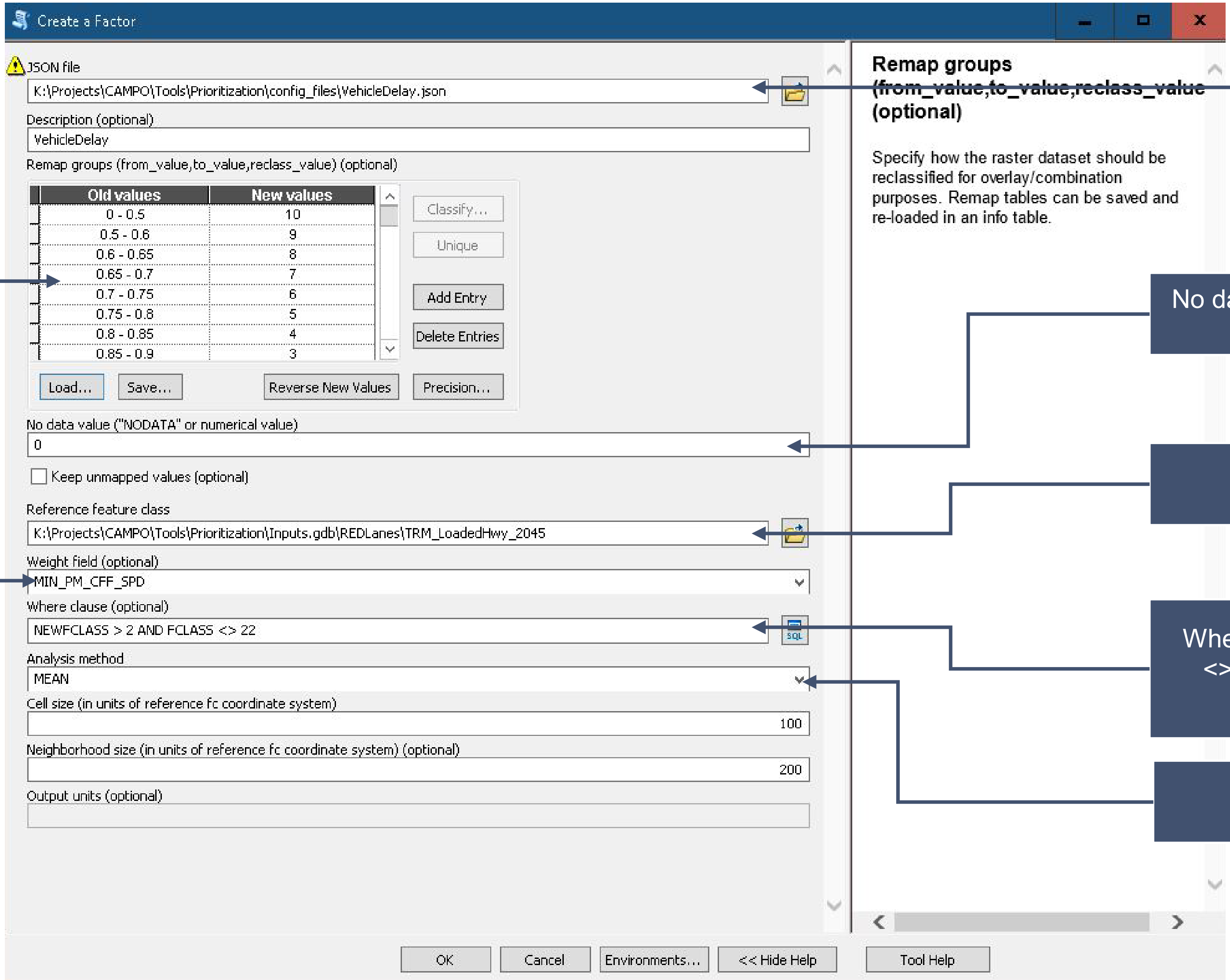
SUITABILITY – HIGHWAY OPERATIONS



SUITABILITY – HIGHWAY OPS – VEHICLE DELAY

Remap groups: load from {remaps_dir}/vehicle_delay

Weight field: MIN_PM_CFF_SPD



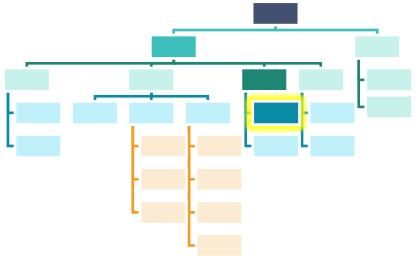
JSON file: {config_dir}\VehicleDelay.json

No data value: 0 (No suitability due to delay if no delay data in neighborhood)

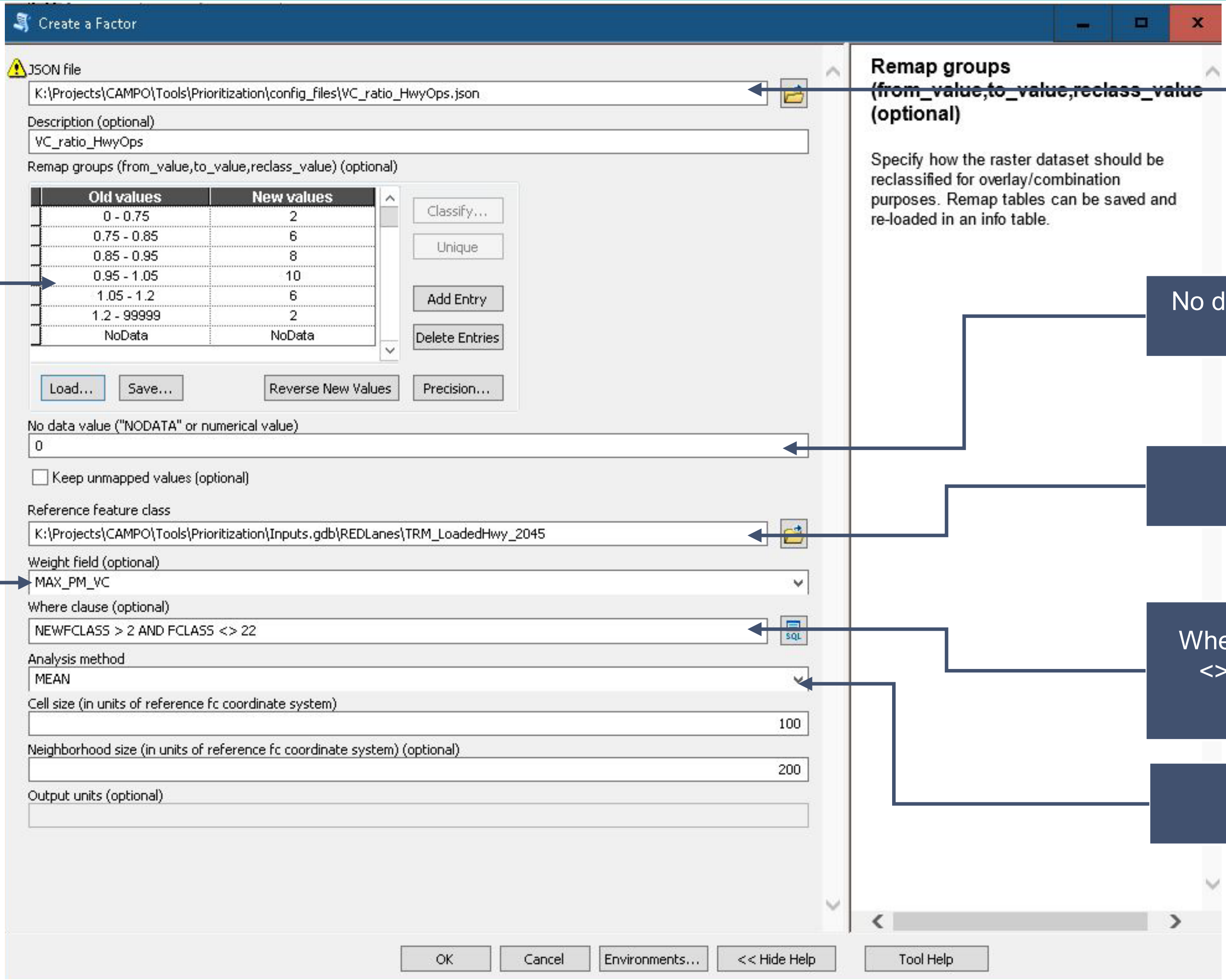
Reference feature class: {inputs_gdb}\TRM_LoadedHwy_2045

Where clause: NEWFCLASS>2 AND FCLASS <>22 (only include non-limited access/non-tollway facilities)

Analysis method: MEAN



SUITABILITY – HIGHWAY OPS – V/C RATIO



Remap groups: load from {remaps_dir}/vc_ratio_hwy_ops

Weight field: MAX_PM_VC

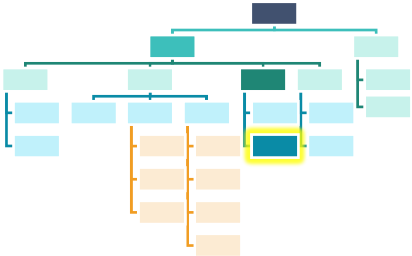
JSON file: {config_dir}\VC_ratio_HwyOps.json

No data value: 0 (No suitability due to v/c ratio if no v/c ratio data in neighborhood)

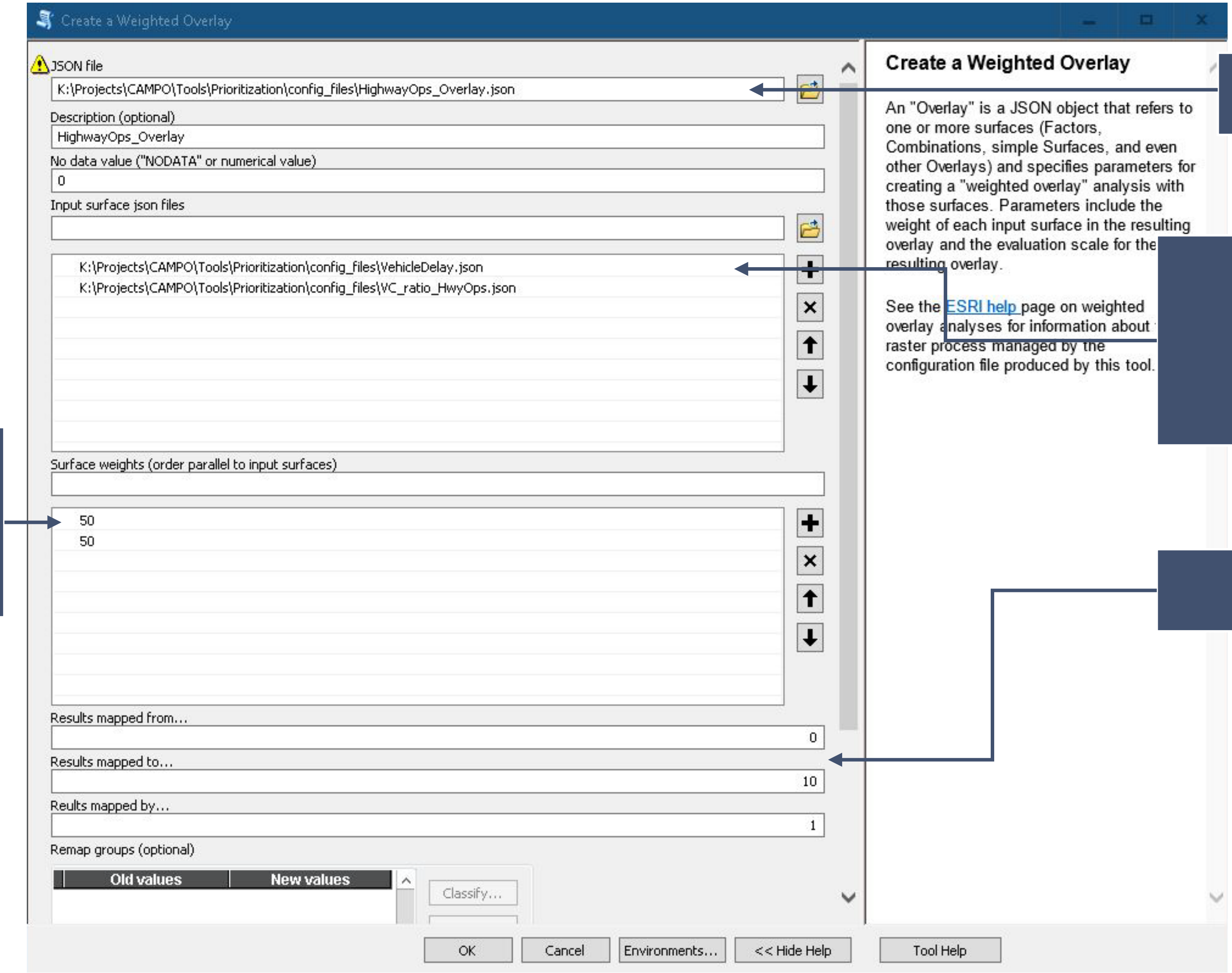
Reference feature class: {inputs_gdb}\TRM_LoadedHwy_2045

Where clause: NEWFCLASS>2 AND FCLASS <>22 (only include non-limited access/non-tollway facilities)

Analysis method: MEAN



SUITABILITY – HIGHWAY OPS – OVERLAY

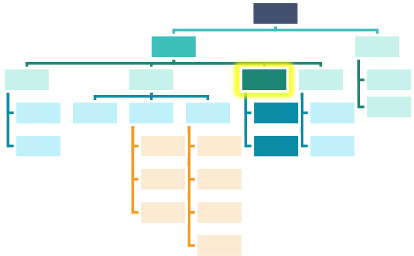


JSON file:
{config_dir}\HighwayOps_Overlay.json

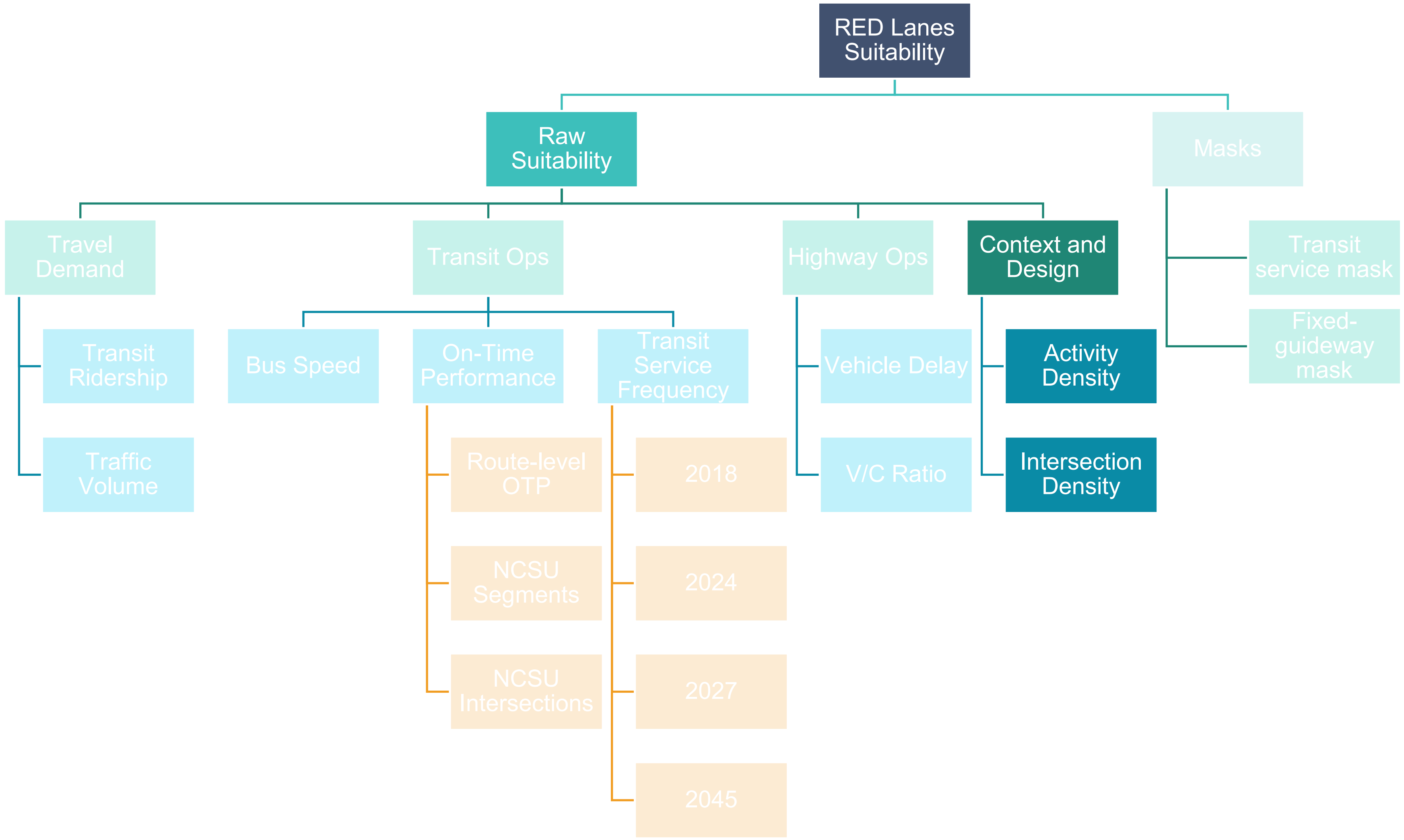
Input surface json files:
{config_dir}\VehicleDelay.json
{config_dir}\VC_ratio_HwyOps.json

Weights:
Vehicle delay: 50
VC ratio: 50

Results mapped from/to/by:
Defaults (0/10/1)



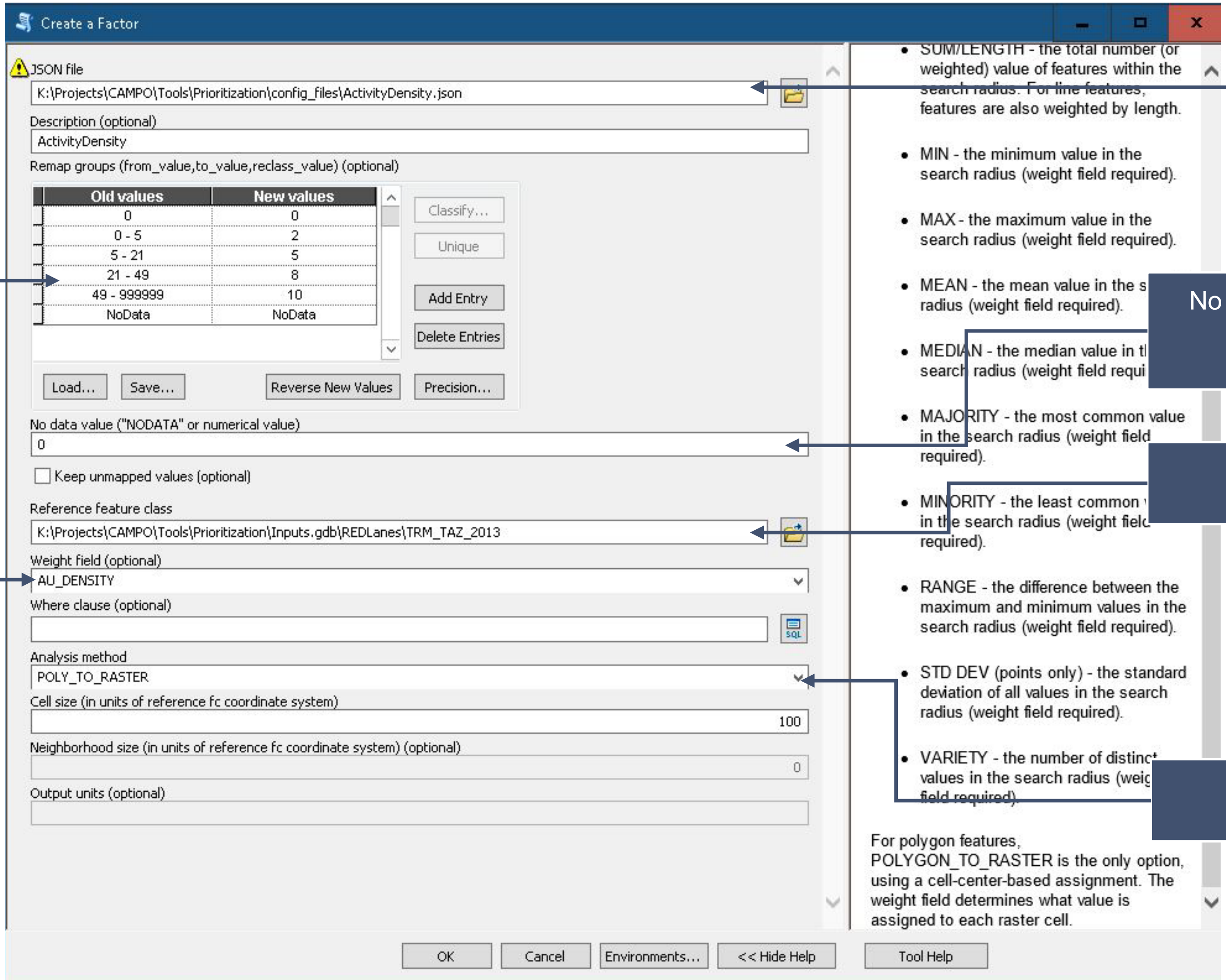
SUITABILITY – CONTEXT AND DESIGN



SUITABILITY – CONTEXT & DESIGN – ACTIVITY DENSITY

Remap groups: load from {remaps_dir}/activity_density

Weight field: AU_DENSITY

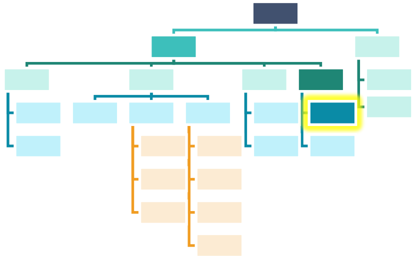


JSON file: {config_dir}\ActivityDensity.json

No data value: 0 (No suitability due to activity density if no activity density data in neighborhood)

Reference feature class: {inputs_gdb}\TRM_TAZ_2013

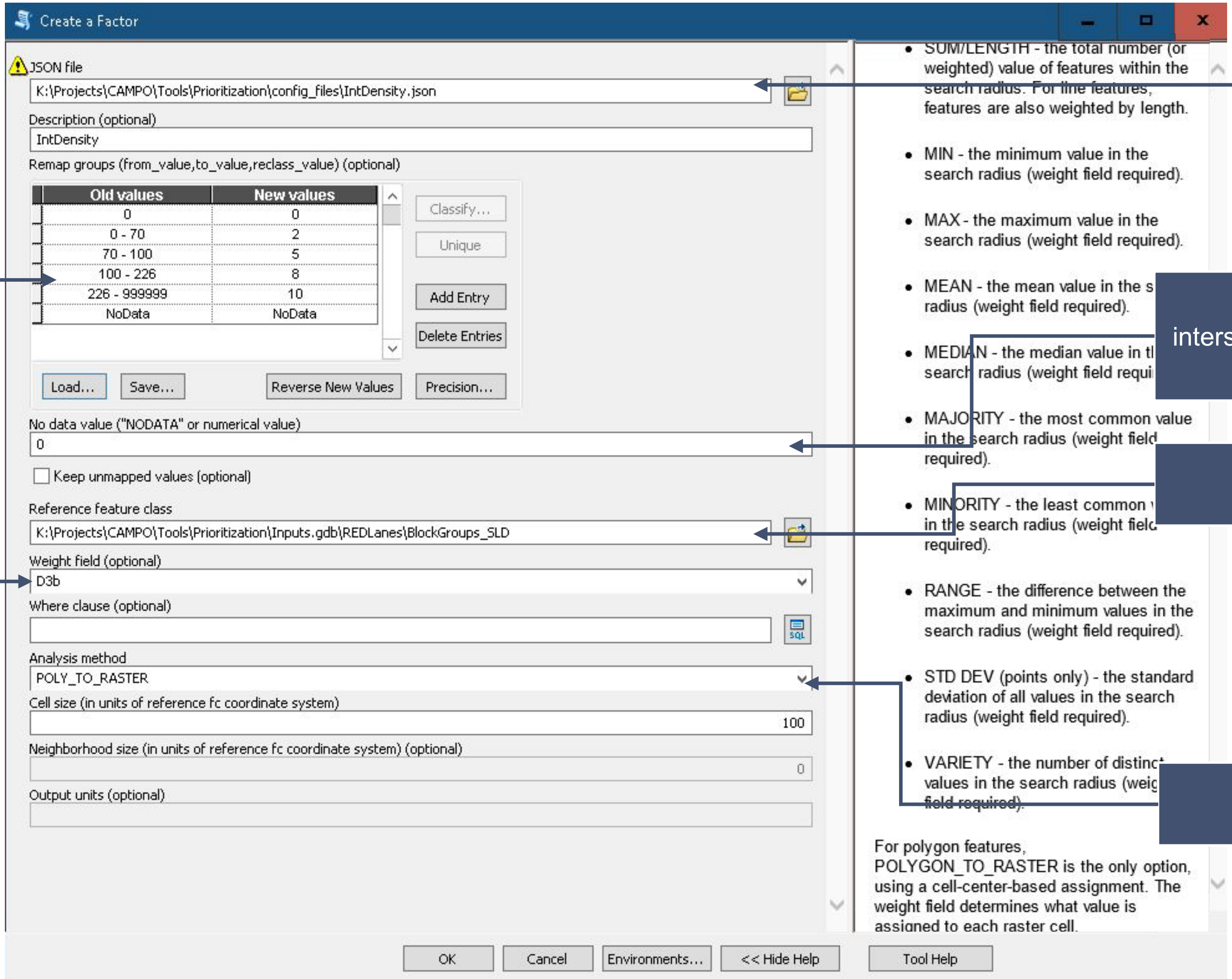
Analysis method: POLY_TO_RASTER



SUITABILITY – CONTEXT & DESIGN – INTERSECTION DENSITY

Remap groups: load from {remaps_dir}/intersection_density

Weight field: D3b

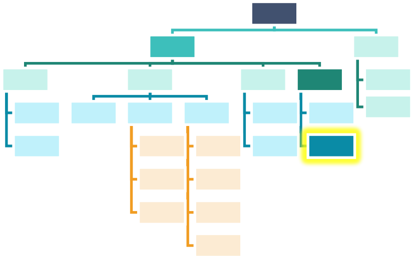


JSON file: {config_dir}\IntDensity.json

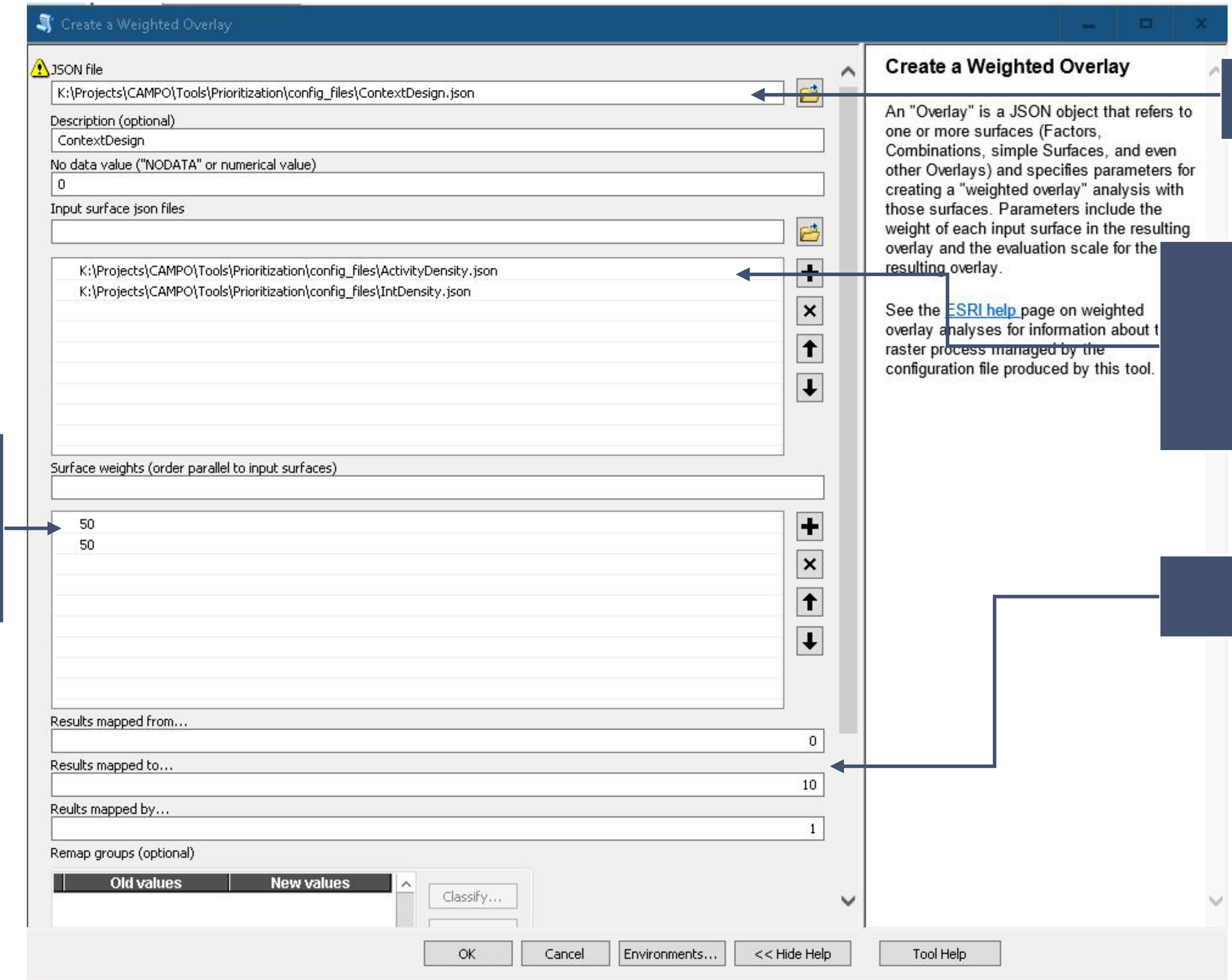
No data value: 0 (No suitability due to intersection density if no intersection density data in neighborhood)

Reference feature class: {inputs_gdb}\BlockGroups_SLD

Analysis method: POLY_TO_RASTER



SUITABILITY – CONTEXT & DESIGN – OVERLAY

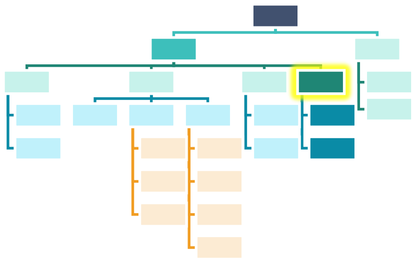


JSON file: {config_dir}\ContextDesign.json

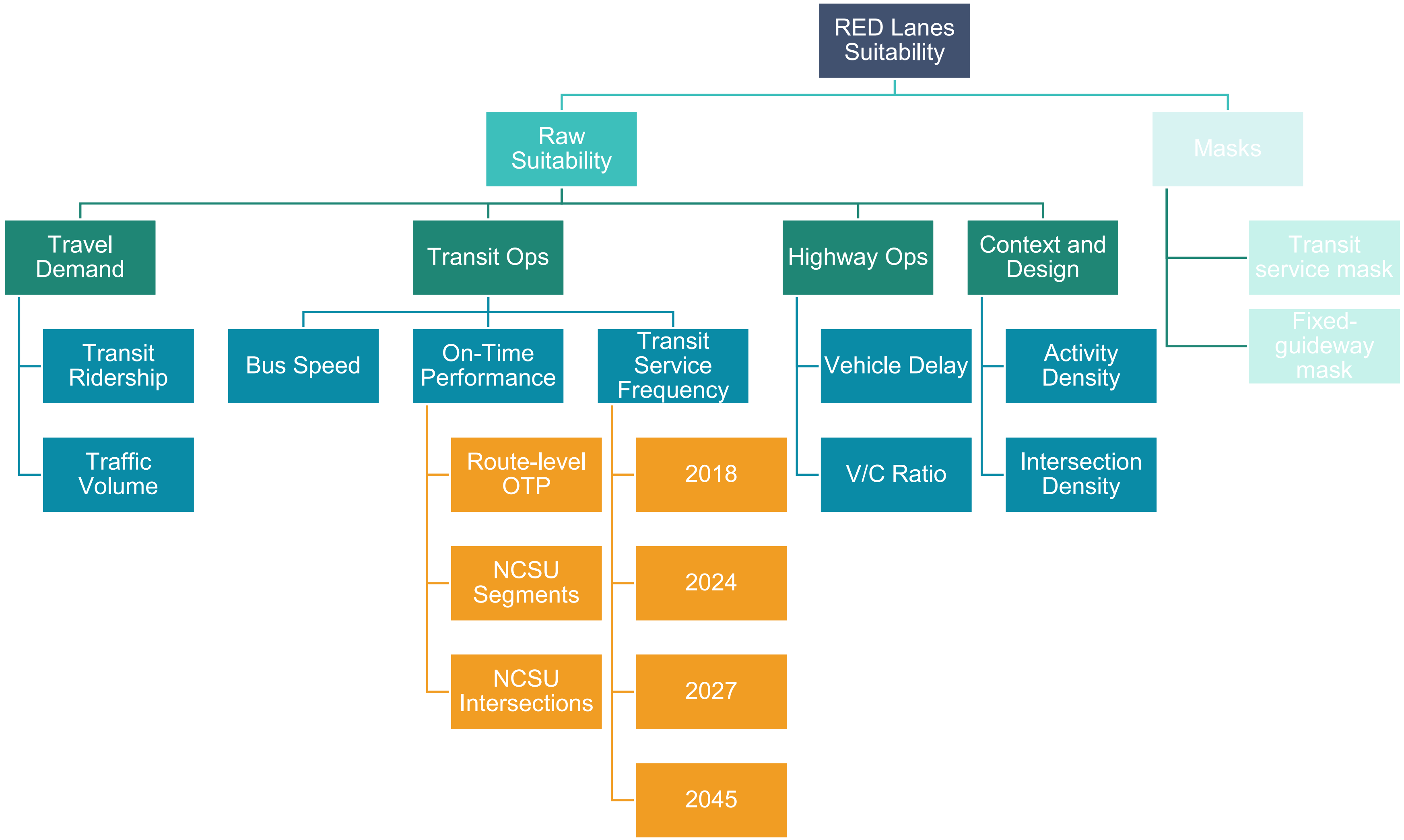
Input surface json files:
{config_dir}\ActivityDensity.json
{config_dir}\IntDensity.json

Weights:
Activity Density: 50
Intersection Density: 50

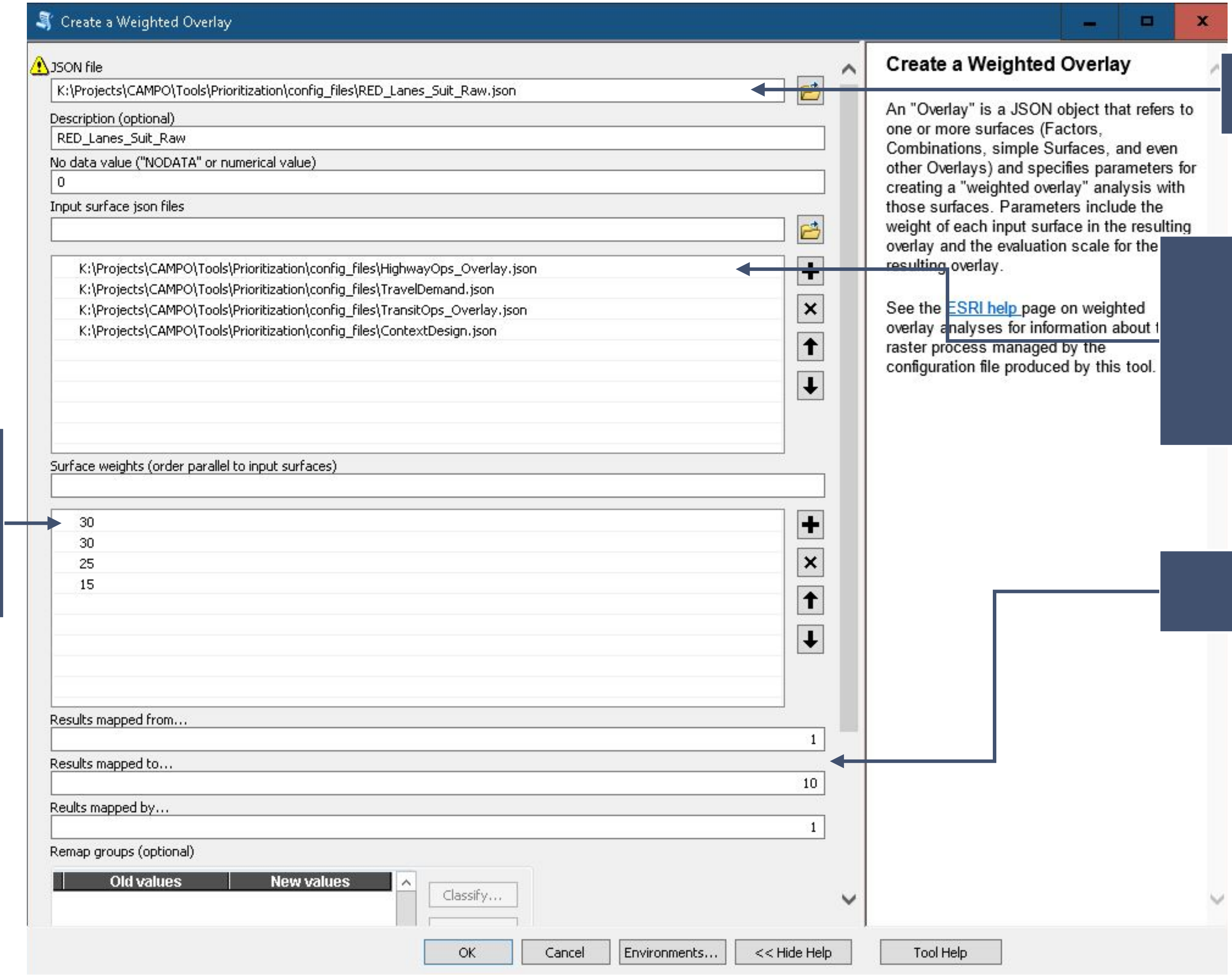
Results mapped from/to/by:
Defaults (0/10/1)



SUITABILITY – RAW SUITABILITY



SUITABILITY – RAW SUITABILITY – OVERLAY

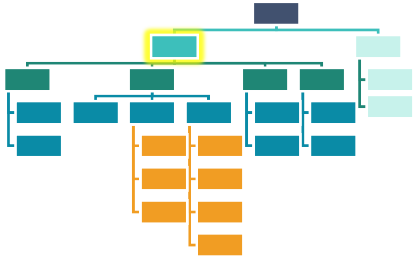


JSON file:
{config_dir}\RED_Lanes_Suit_Raw.json

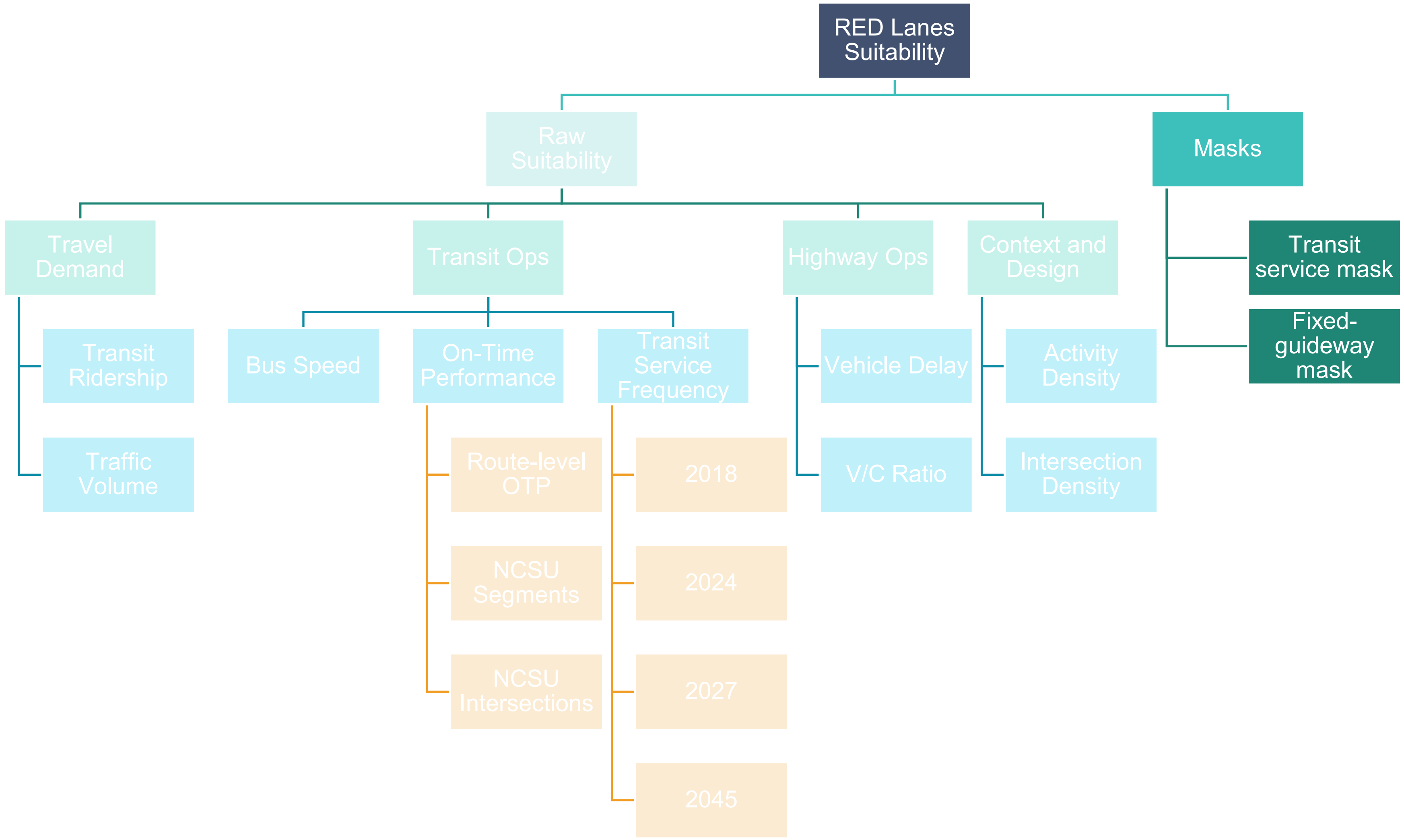
Input surface json files:
{config_dir}\HighwayOps_Overlay.json
{config_dir}\TravelDemand.json
{config_dir}\TransitOps_Overlay.json
{config_dir}\ContextDesign.json

Weights:
Highway Operations: 30
Travel Demand: 30
Transit Operations: 25
Context Design: 15

Results mapped from/to/by:
Defaults (0/10/1)



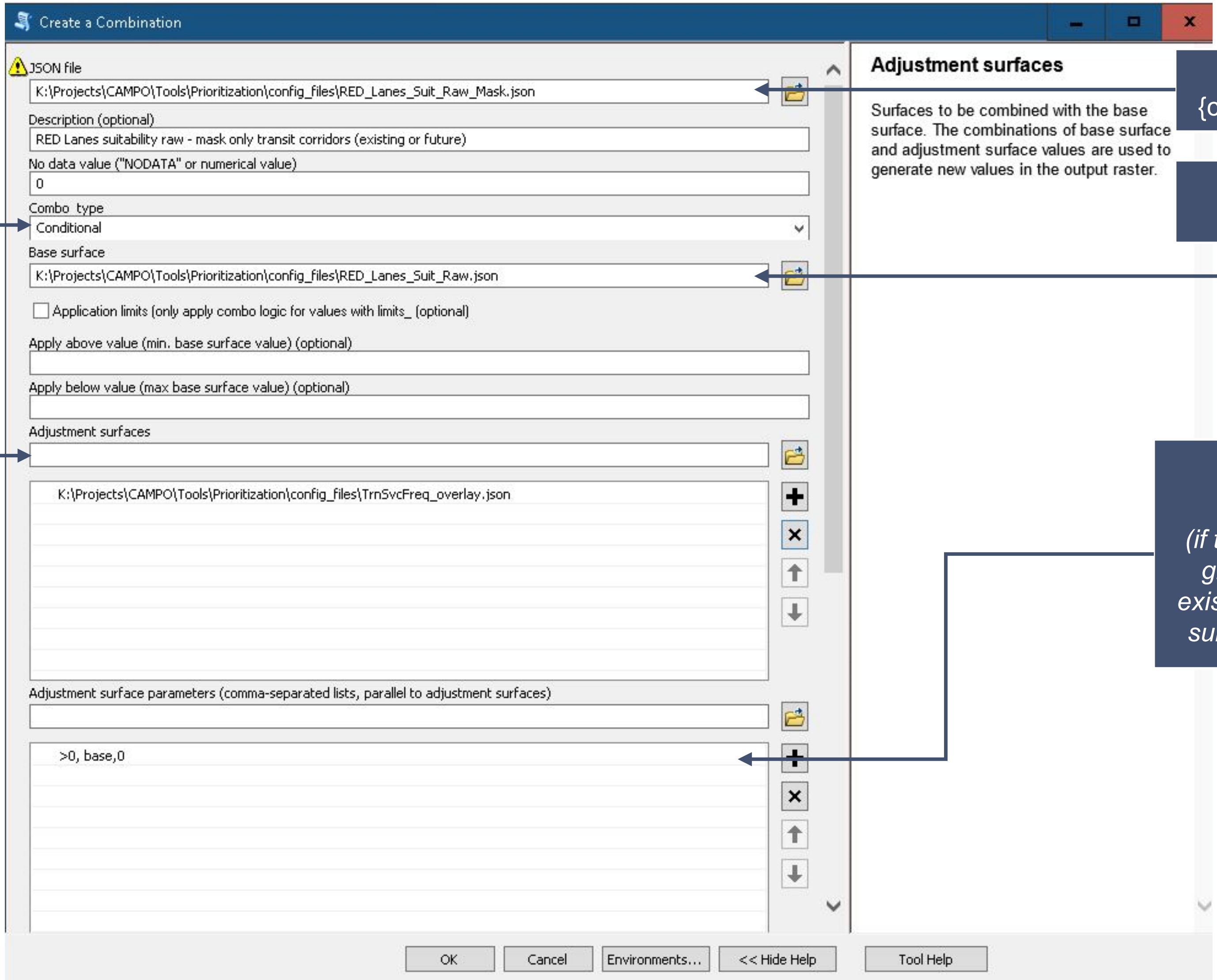
SUITABILITY – MASKING RESULTS



SUITABILITY – MASKS – SUITABILITY COMBO W/ TRANSIT MASK

Combo type: Conditional

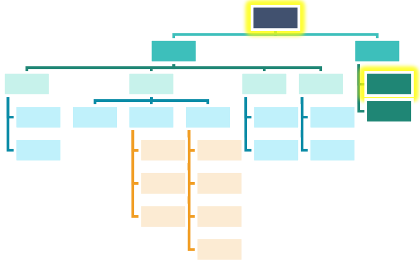
Adjustment surfaces:
{config_dir}\TrnSvcFreq_overlay



JSON file:
{config_dir}\RED_Lanes_Suit_Raw_Mask.json

Base surface:
{config_dir}\RED_Lanes_Suit_Raw.json

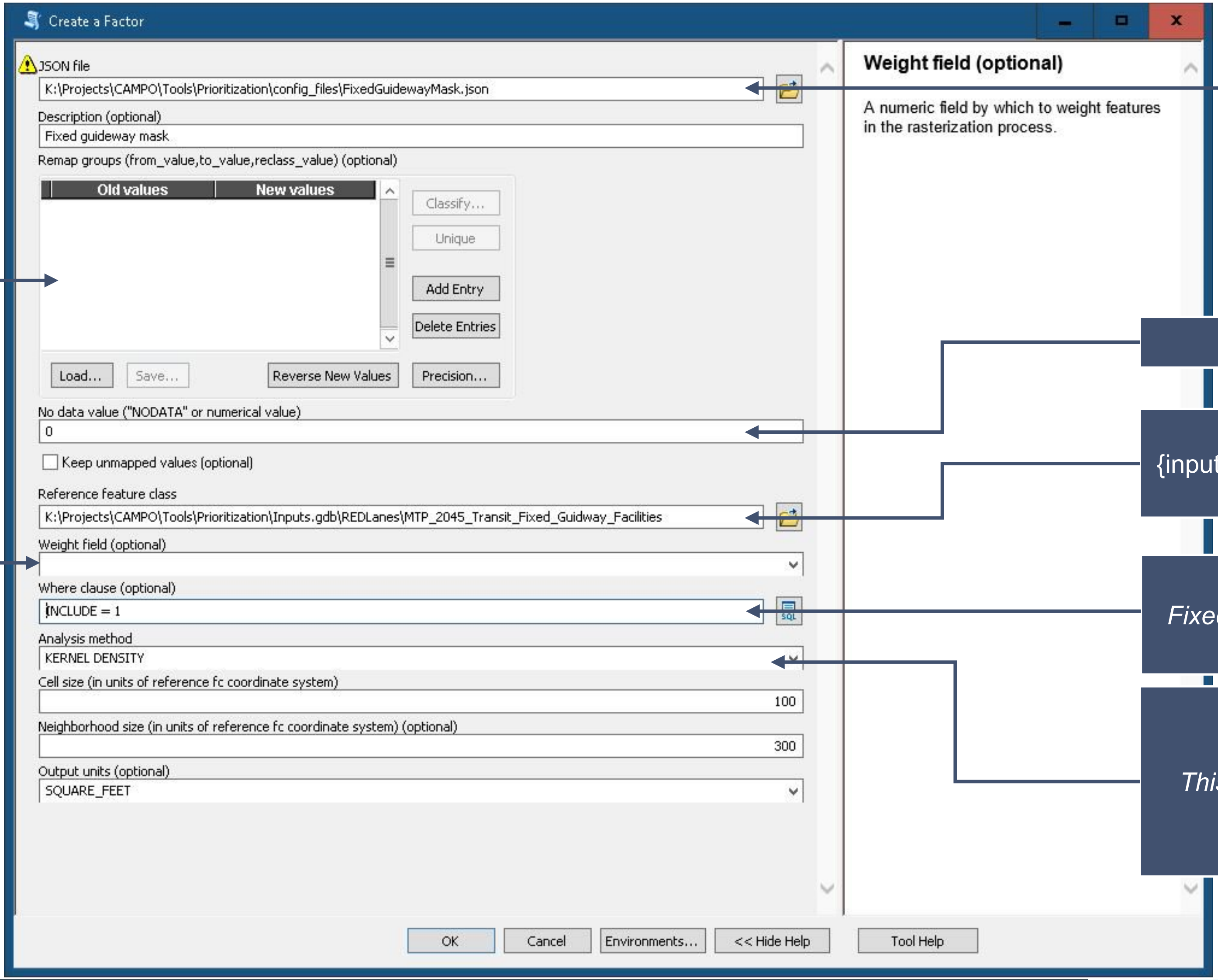
Adjustment surface parameters:
>0,base,0
(if the transit service frequency overlay score is greater than zero [i.e., there is at least some existing or planned transit service], keep the raw suitability score, else set the cell value to zero)



SUITABILITY – MASKS – CREATING A FIXED GUIDEWAY MASK

Remap groups: (none)

Weight field: (none)



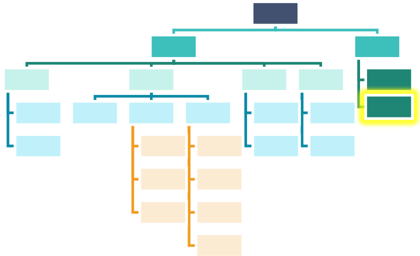
JSON file: {config_dir}\FixedGuidewayMask.json

No data value: 0

Reference feature class: {inputs_gdb}\MTP_2045_Transit_Fixed_Guideway_Facilitiies

Where clause: INCLUDE=1
Fixed guideway facilities that should be masked are flagged in this field.

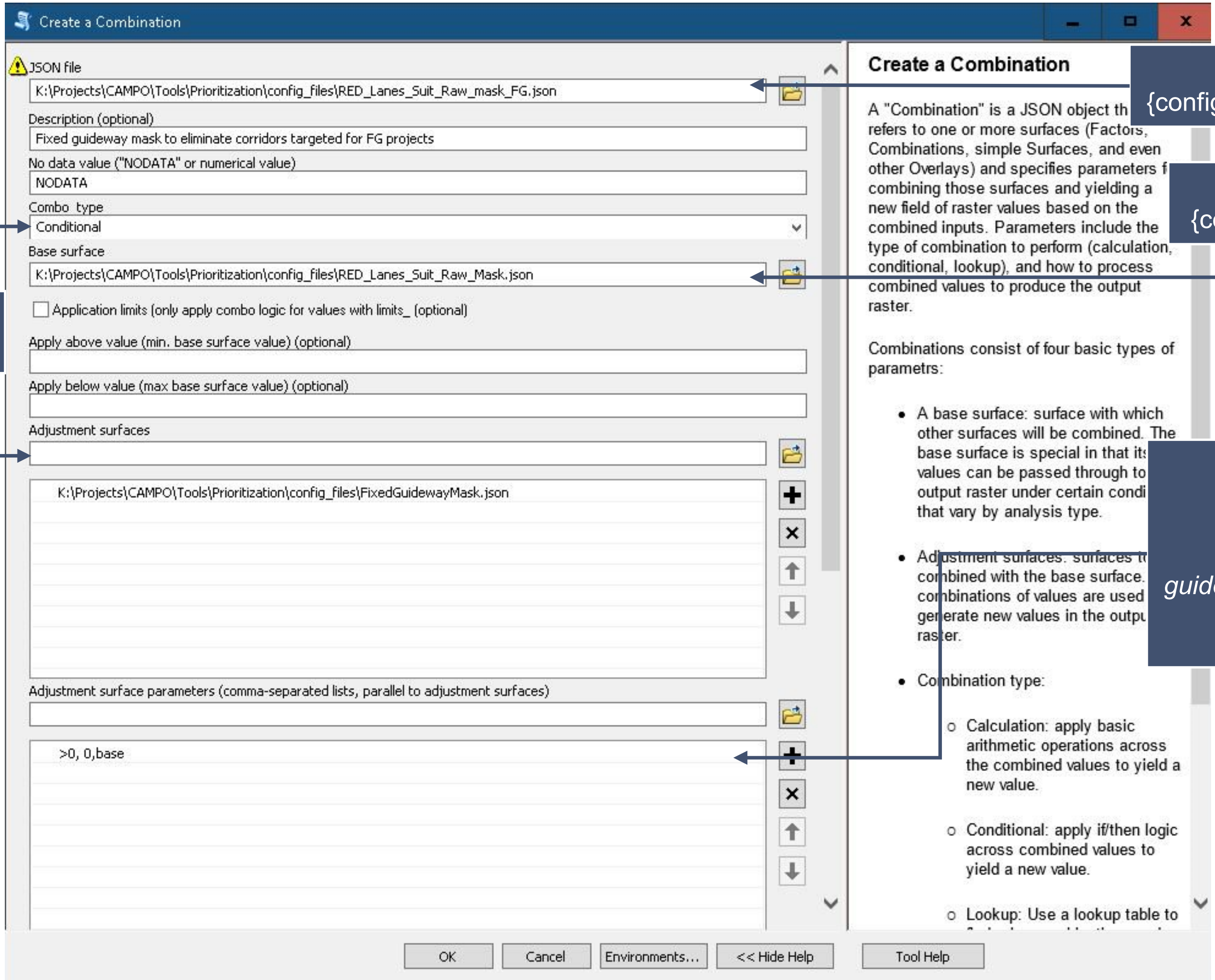
Analysis method: KERNEL DENSITY
This allows us to use no weight field, and any value > 0 can be used downstream



SUITABILITY – MASKS – ADDING THE FIXED GUIDEWAY MASK

Combo type: Conditional

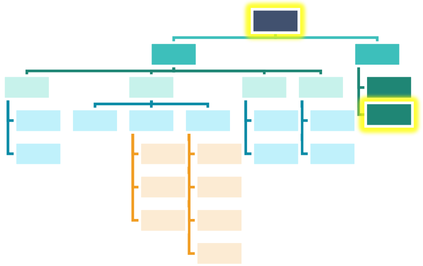
Adjustment surfaces:
{config_dir}\FixedGuidewaMask.json



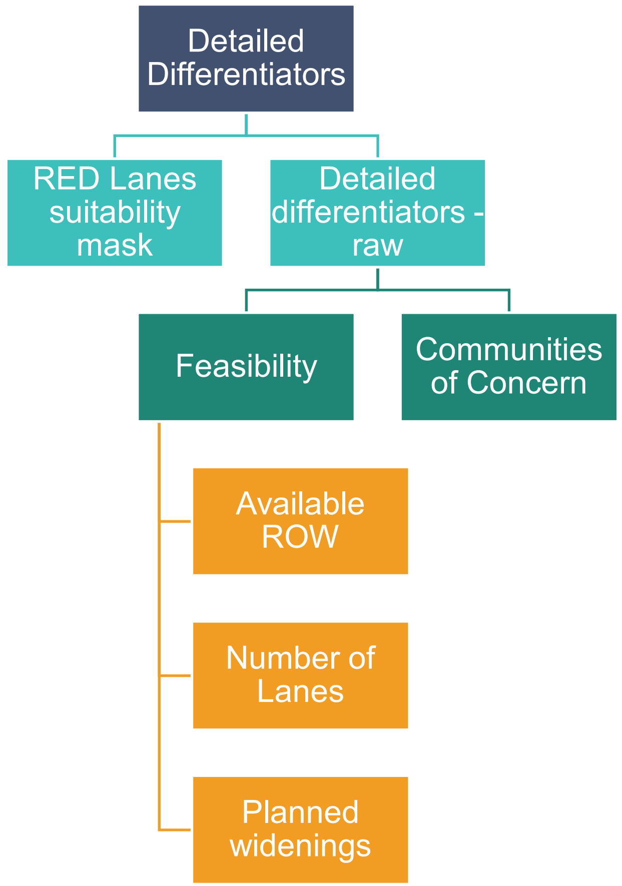
JSON file:
{config_dir}\RED_Lanes_Suit_Raw_mask_FG.json

Base surface:
{config_dir}\RED_Lanes_Suit_Raw_Mask.json

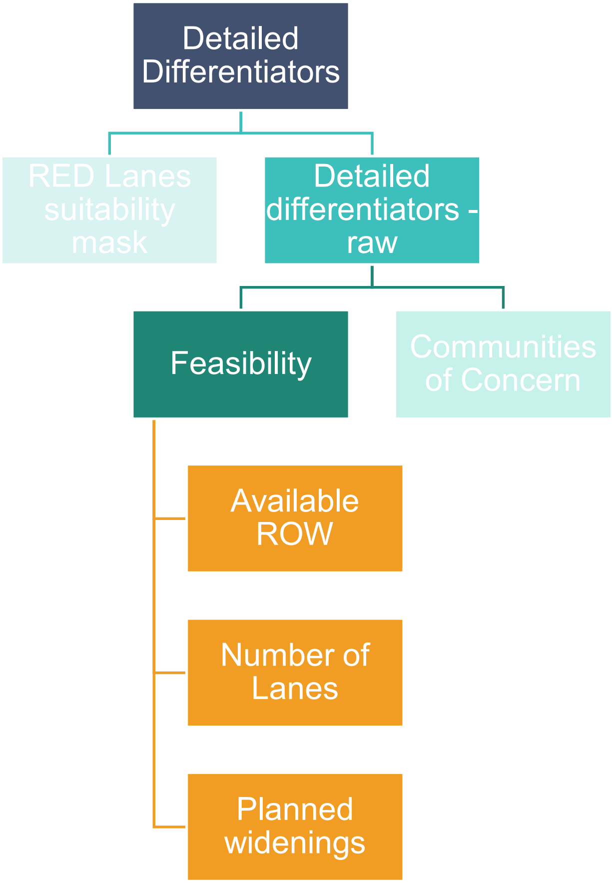
Adjustment surface parameters:
>0,0,base
(if the cell overlaps with a planned fixed guideway project, set the value to zero, otherwise retain the base value)



DETAILED DIFFERENTIATORS



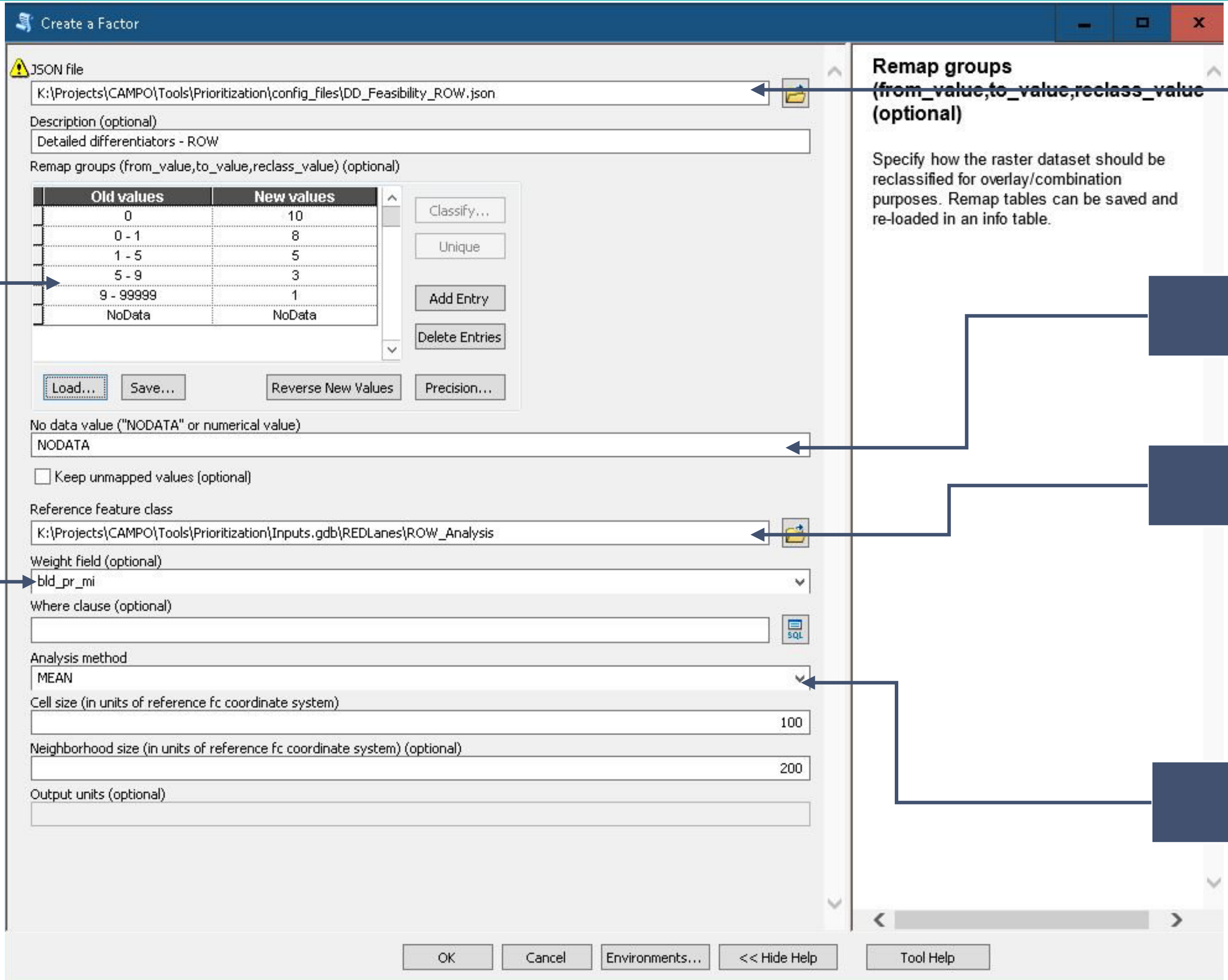
DETAILED DIFFERENTIATORS - FEASIBILITY



DETAILED DIFFERENTIATORS – FEASIBILITY – AVAILABLE ROW

Remap groups: load from {remaps_dir}/DD_Feasibility_ROW

Weight field: bld_pr_mi

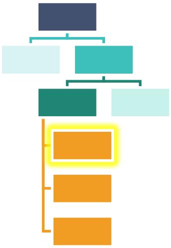


JSON file: {config_dir}\DD_Feasibility_ROW.json

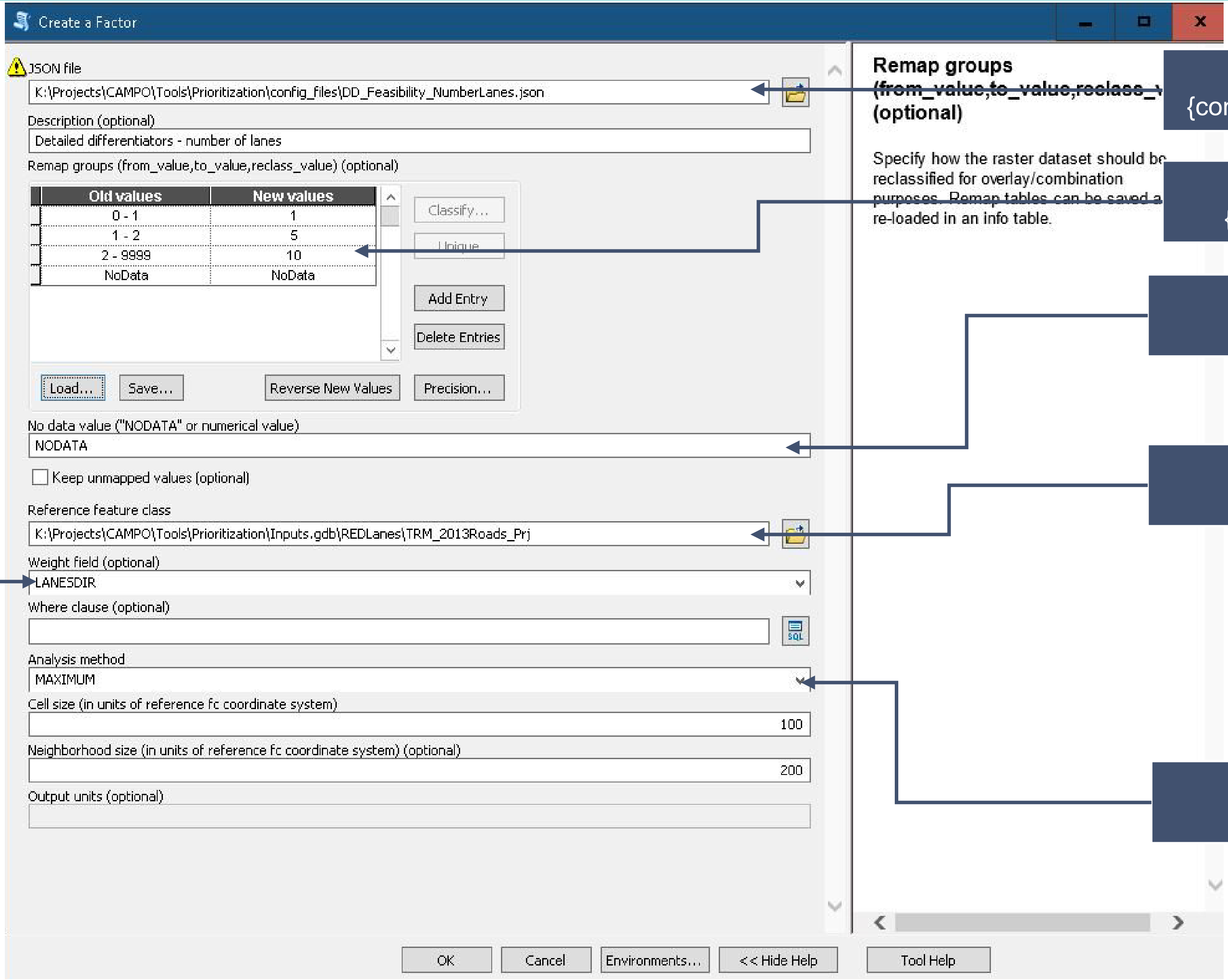
No data value: NODATA

Reference feature class: {inputs_gdb}\ROW_Analysis

Analysis method: MEAN



DETAILED DIFFERENTIATORS – FEASIBILITY – WIDENING



JSON file: {config_dir}\DD_Feasibility_NumberLanes.json

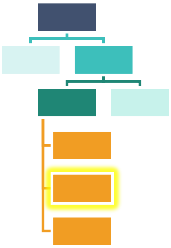
Remap groups: load from {remaps_dir}/DD_Feasibility_NumLanes

No data value: NODATA

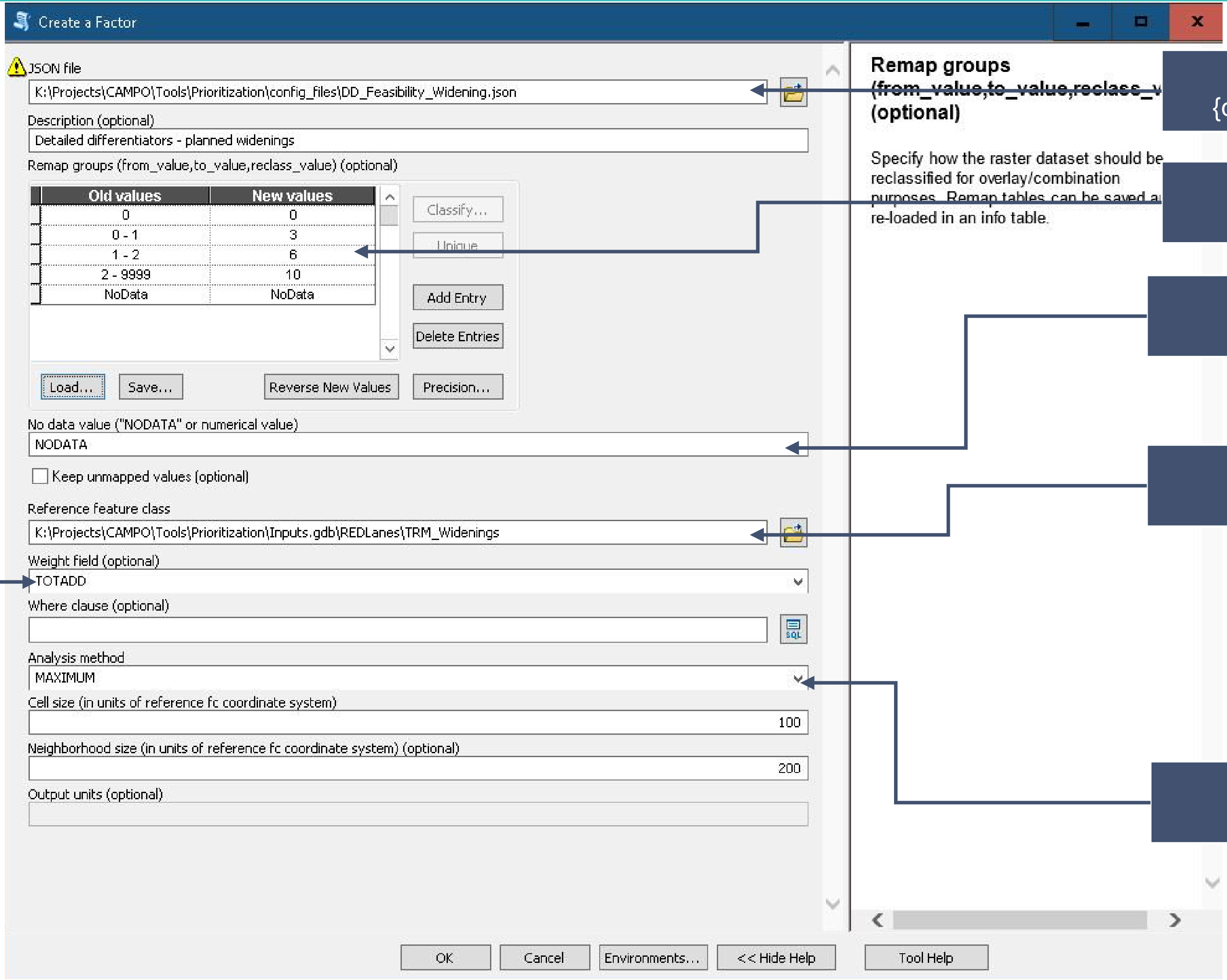
Reference feature class: {inputs_gdb}\TRM_2013Roads_Prj

Weight field: LANESDIR

Analysis method: MAXIMUM



DETAILED DIFFERENTIATORS – FEASIBILITY – WIDENING



JSON file:
{config_dir}\DD_Feasibility_Widening.json

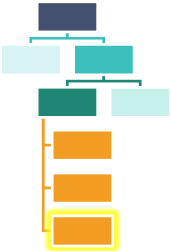
Remap groups: load from
{remaps_dir}/DD_Feasibility_Widening

No data value: NODATA

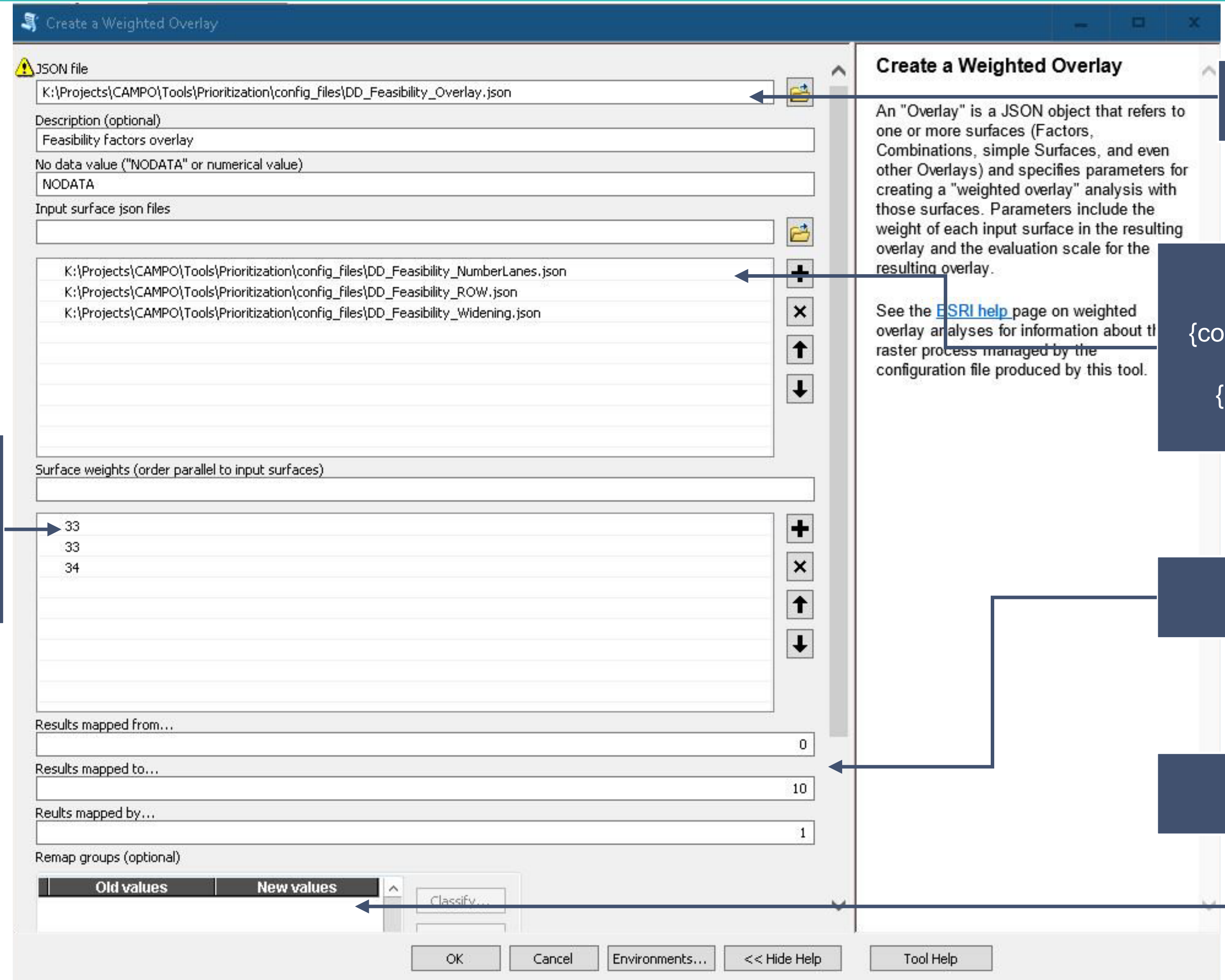
Reference feature class:
{inputs_gdb}\TRM_Widenings

Weight field: TOTADD

Analysis method: MAXIMUM



DETAILED DIFFERENTIATORS – FEASIBILITY – OVERLAY



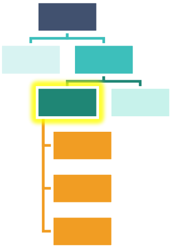
JSON file:
{config_dir}\DD_Feasibility_Overlay.json

Input surface json files:
{config_dir}\DD_Feasibility_NumberLanes.json
{config_dir}\DD_Feasibility_ROW.json
{config_dir}\DD_Feasibility_Widening.json

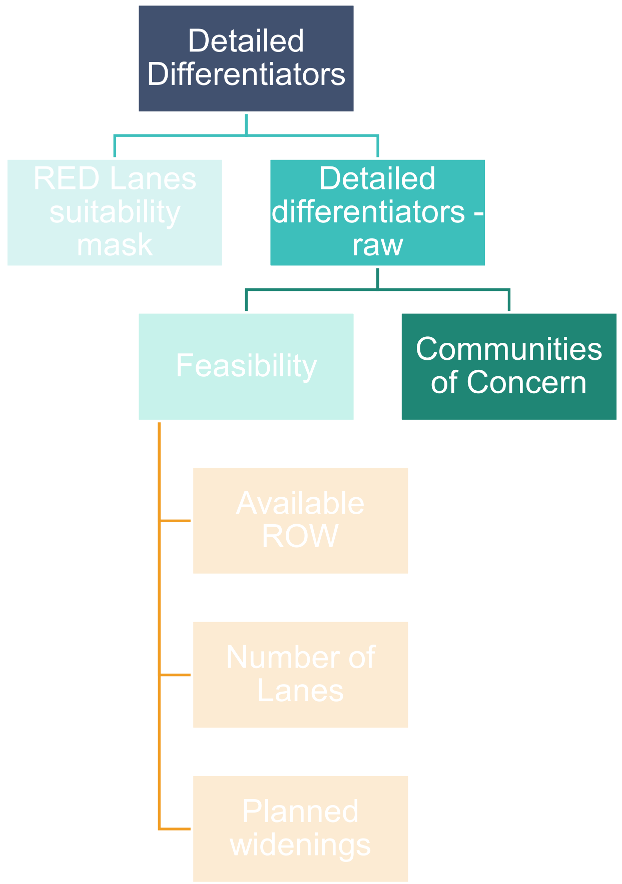
Weights:
Number of Lanes: 33
Available ROW: 33
Widenings: 34

Results mapped from/to/by:
Defaults (0/10/1)

Remap groups: load from
{remaps_dir}/DD_Feasibility_Overlay



DETAILED DIFFERENTIATORS – COMMUNITIES OF CONCERN



DETAILED DIFFERENTIATORS – COMMUNITIES OF CONCERN

Remap groups: load from {remaps_dir}/DD_CommunitiesOfConcern

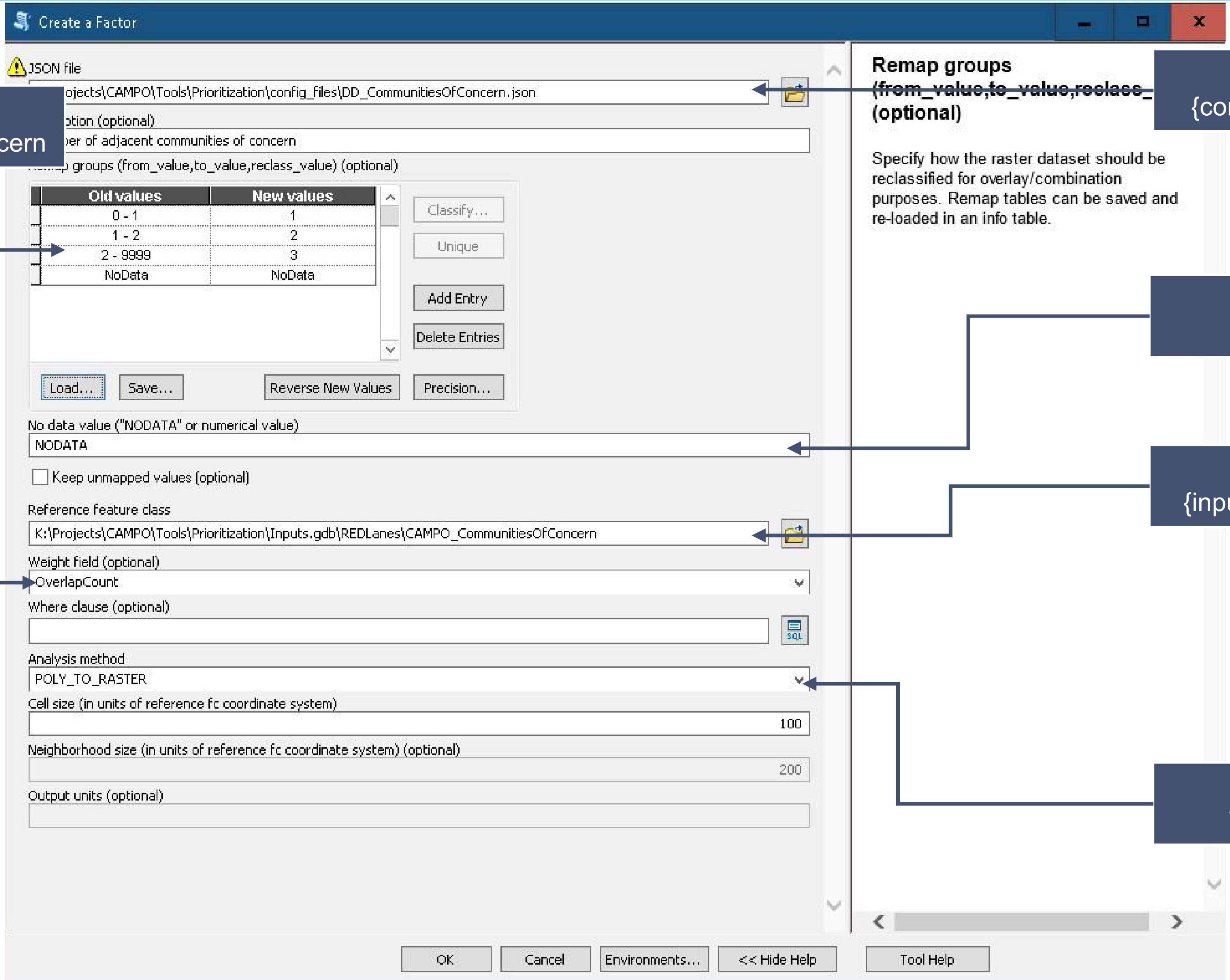
Weight field: OverlapCount

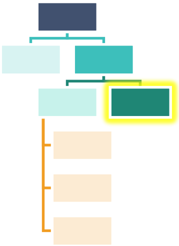
JSON file: {config_dir}\DD_CommunitiesOfConcern.json

No data value: NODATA

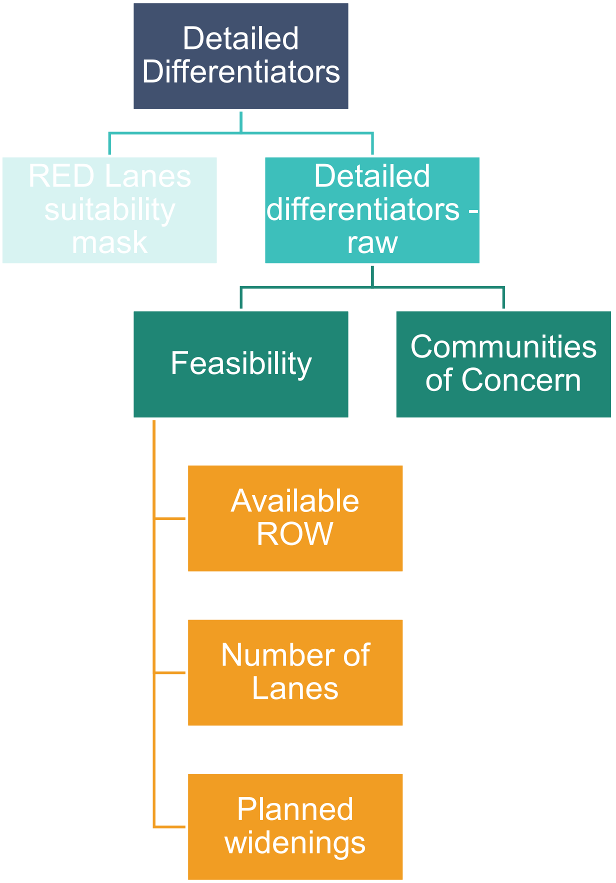
Reference feature class: {inputs_gdb}\CAMPO_CommunitiesofConcern

Analysis method: POLY_TO_RASTER





DETAILED DIFFERENTIATORS – RAW COMBO

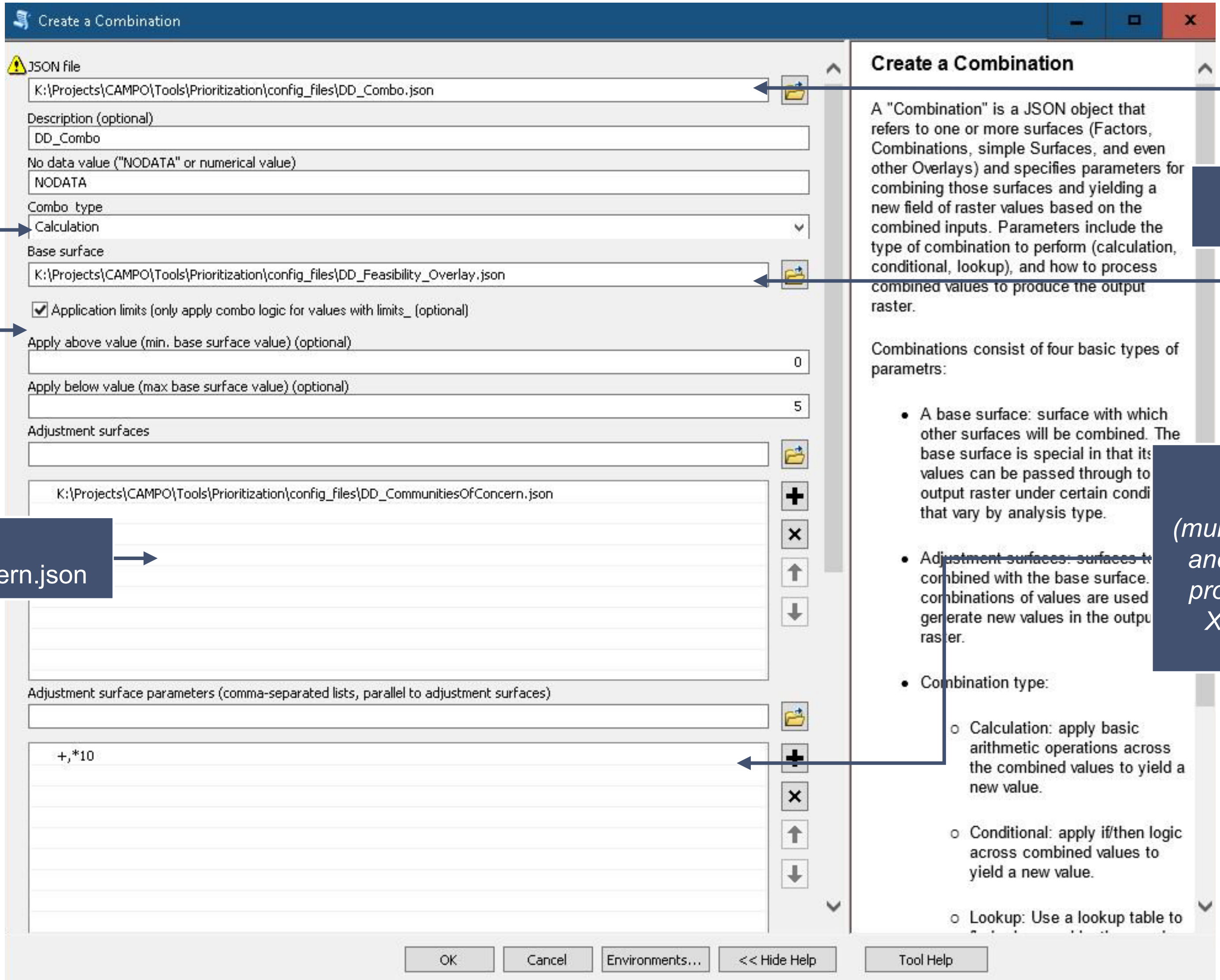


DETAILED DIFFERENTIATORS – RAW COMBO

Combo type: Calculation

Application limits:
Apply above: 0
Apply Below: 5

Adjustment surfaces:
{config_dir}\DD_CommunitiesOfConcern.json

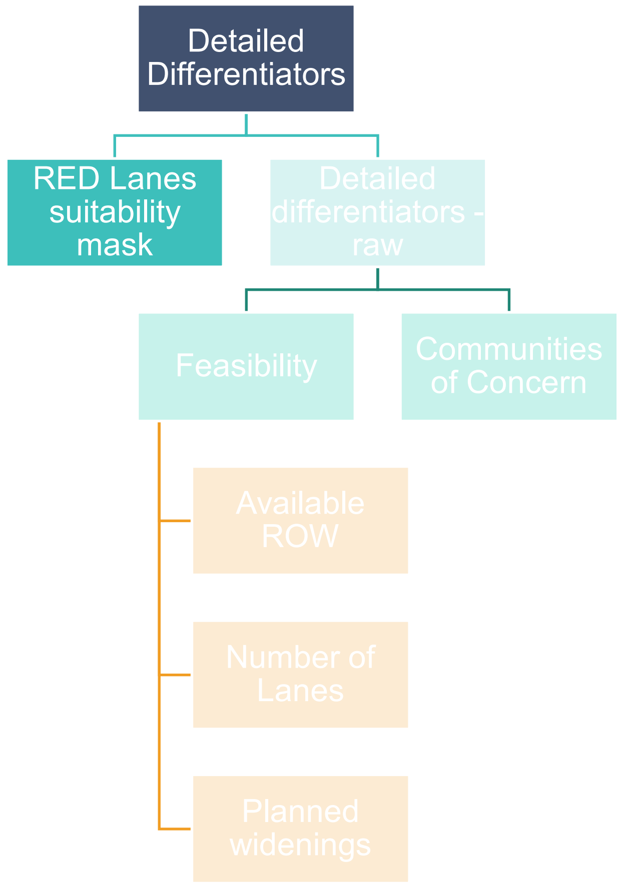


JSON file: {config_dir}\DD_Combo.json

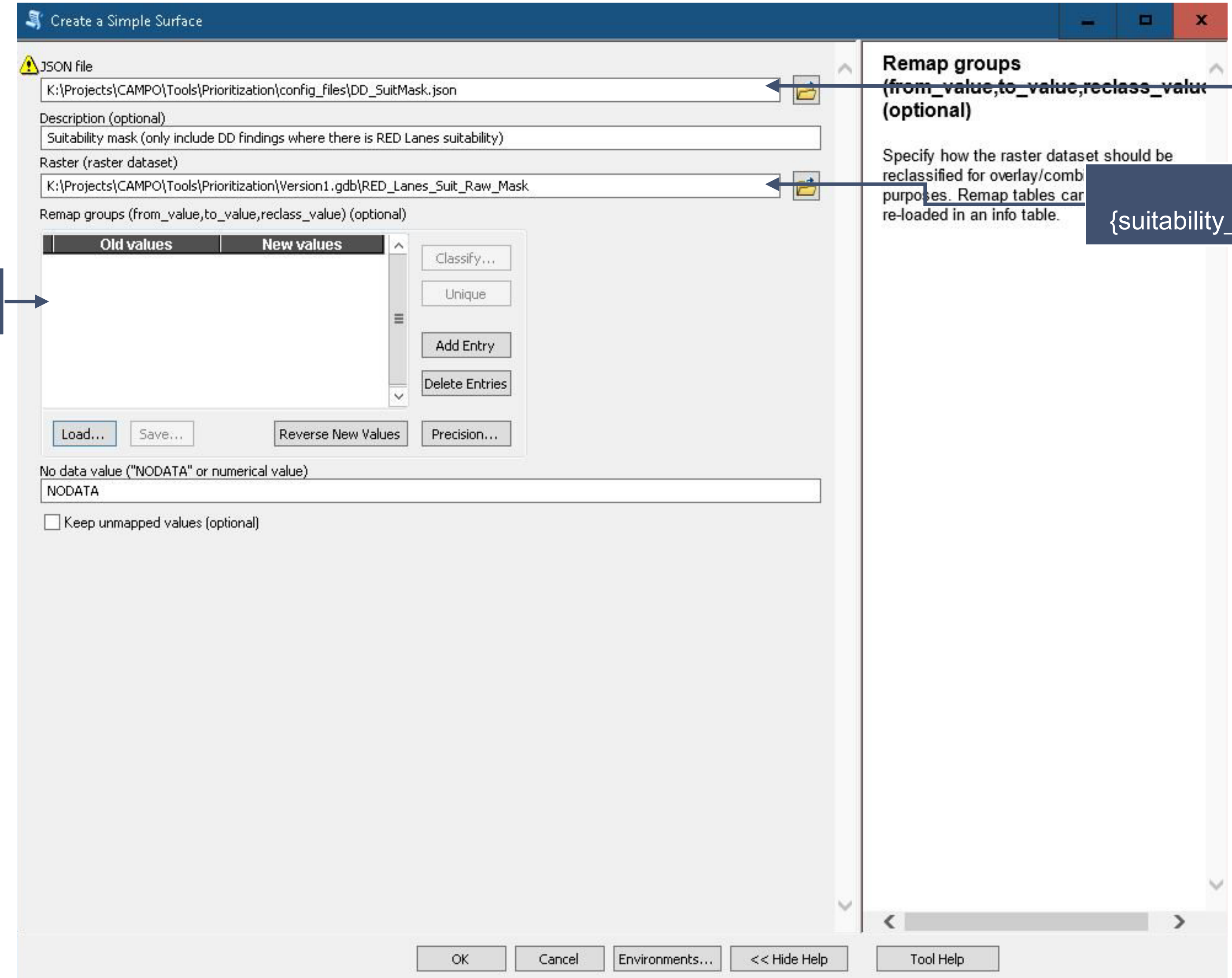
Base surface:
{config_dir}\DD_Feasibility_Overlay.json

Adjustment surface parameters:
+,*10
(multiply the communities of concern value by 10 and add it to the feasibility overlay value – this produces a raster with two-digit output values, XY, where X is the CofC score and Y is the feasibility score)

DETAILED DIFFERENTIATORS – MASKING



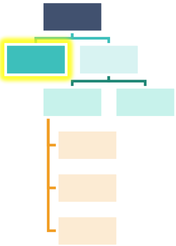
DETAILED DIFFERENTIATORS – SUITABILITY MASK



JSON file:
{config_dir}\DD_SuitMask.json

Raster:
{suitability_outputs_gdb}\RED_Lanes_Suit_Raw_Mask

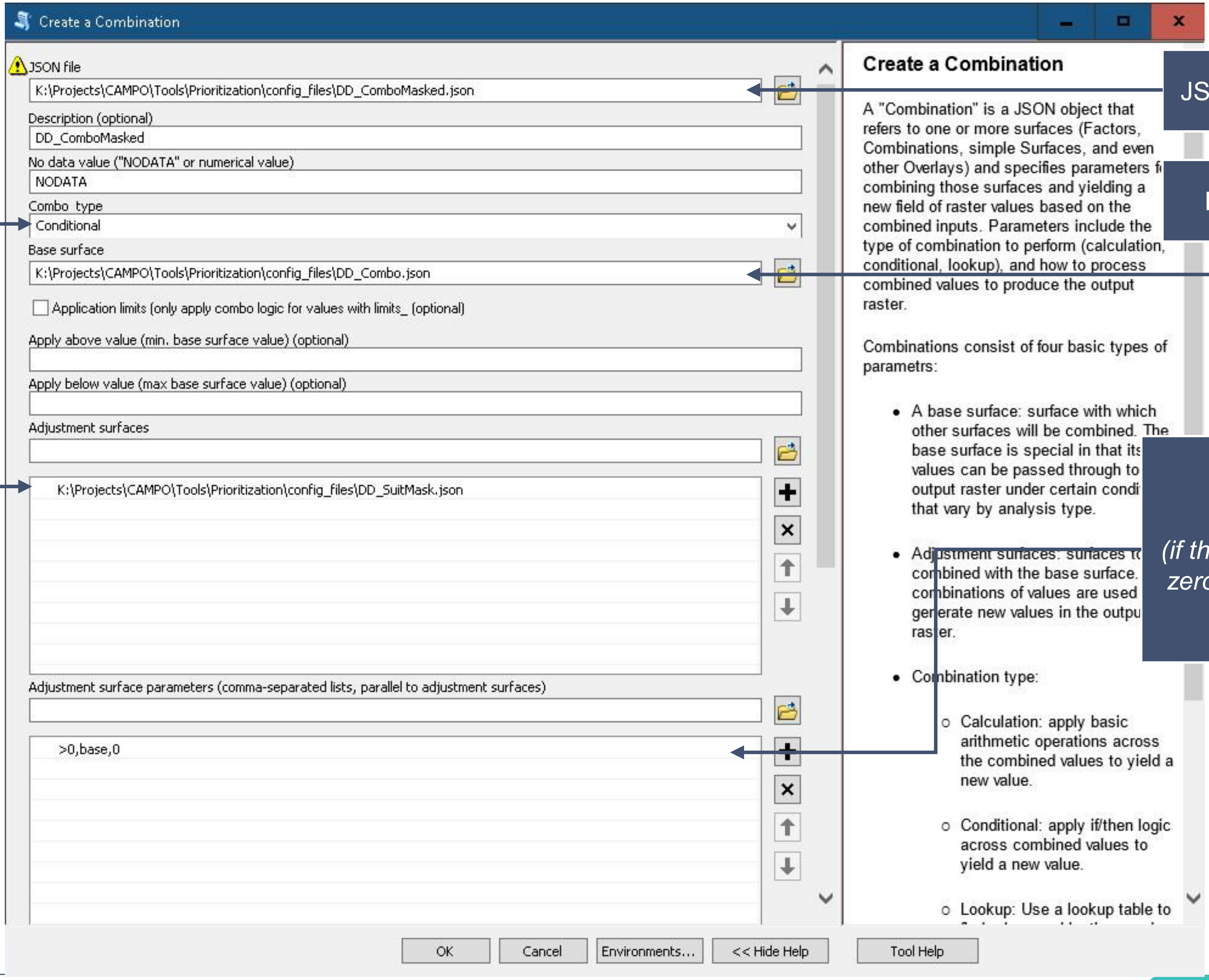
Remap groups: (none)



DETAILED DIFFERENTIATORS – ADDING THE SUITABILITY MASK

Combo type: Conditional

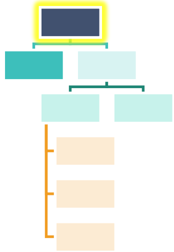
Adjustment surfaces: {config_dir}\DD_SuitMask.json



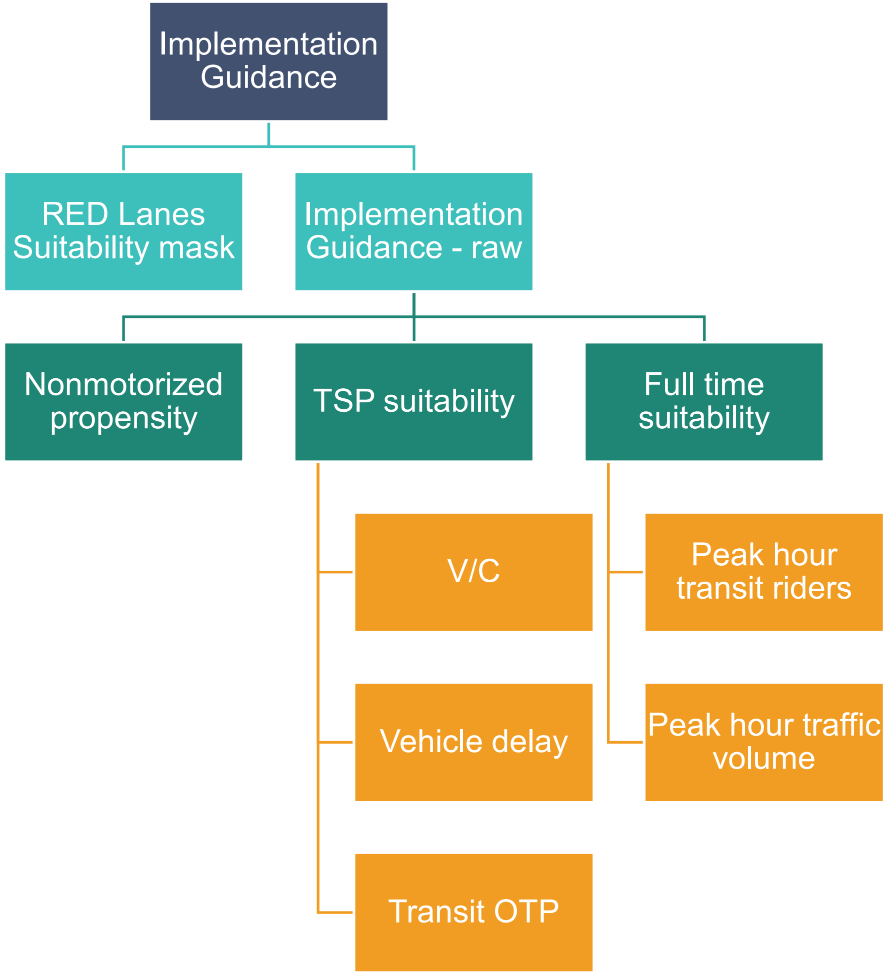
JSON file: {config_dir}\DD_ComboMasked.json

Base surface: {config_dir}\DD_Combo.json

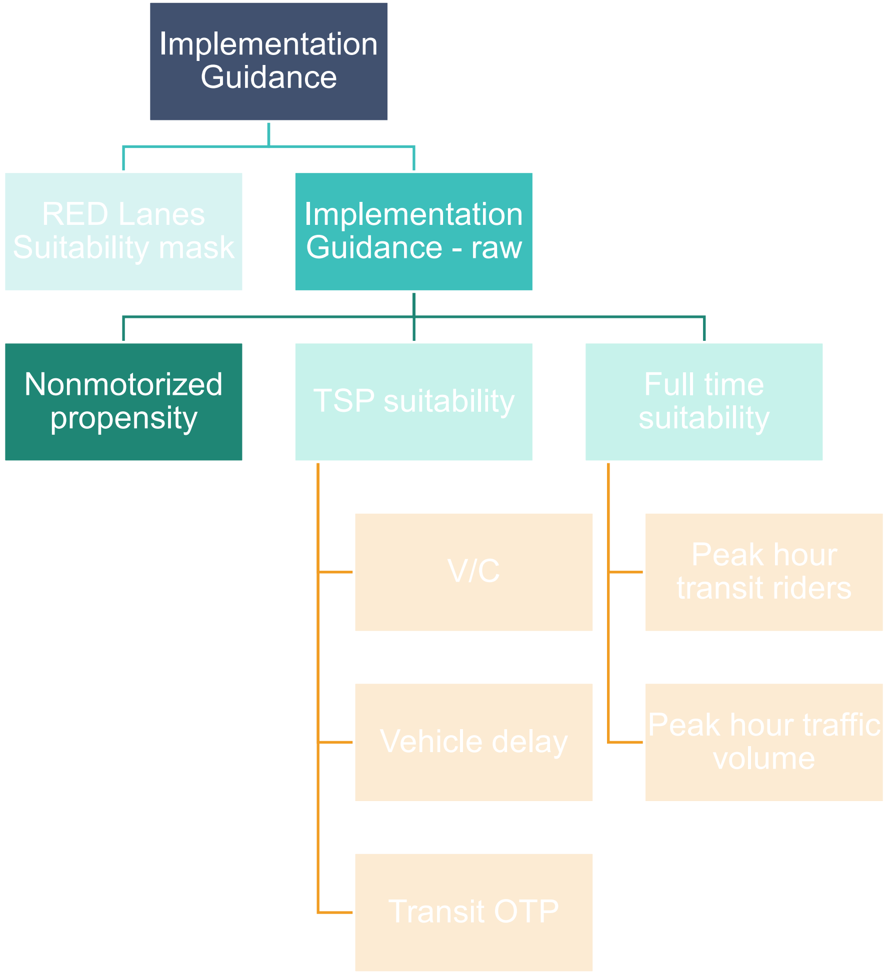
Adjustment surface parameters:
>0,base,0
(if the RED Lanes suitability score is greater than zero keep the DD combo score, else set the cell value to zero)



IMPLEMENTATION GUIDANCE



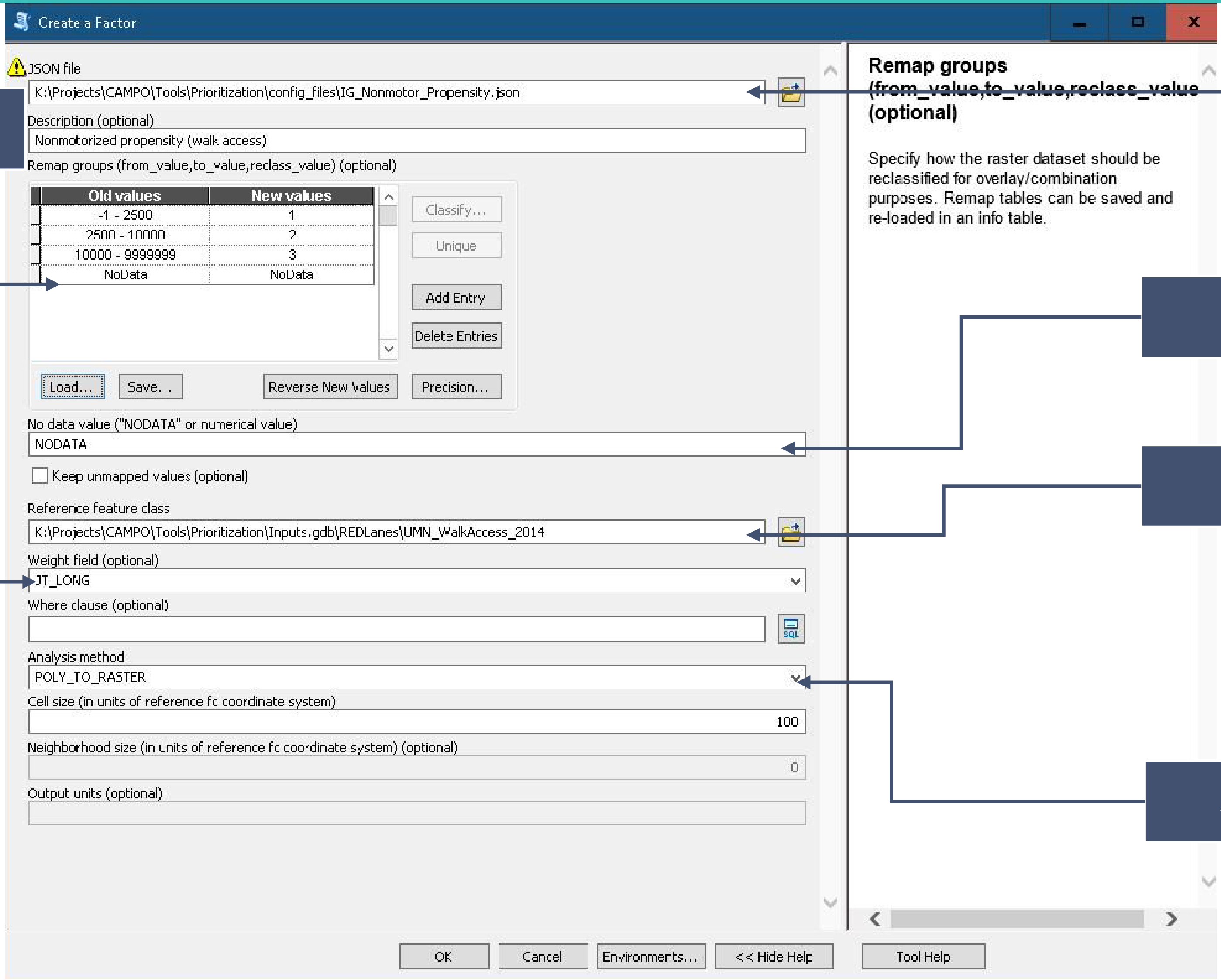
IMPLEMENTATION GUIDANCE – NONMOTORIZED PROPENSITY



IMPLEMENTATION GUIDANCE – NONMOTORIZED PROPENSITY

Remap groups: load from {remaps_dir}/IG_Nonmotor_Prop

JSON file: {config_dir}\IG_Nonmotor_Propensity.json

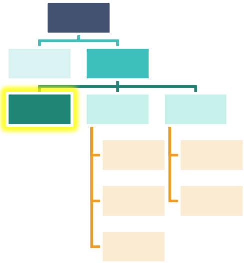


No data value: NODATA

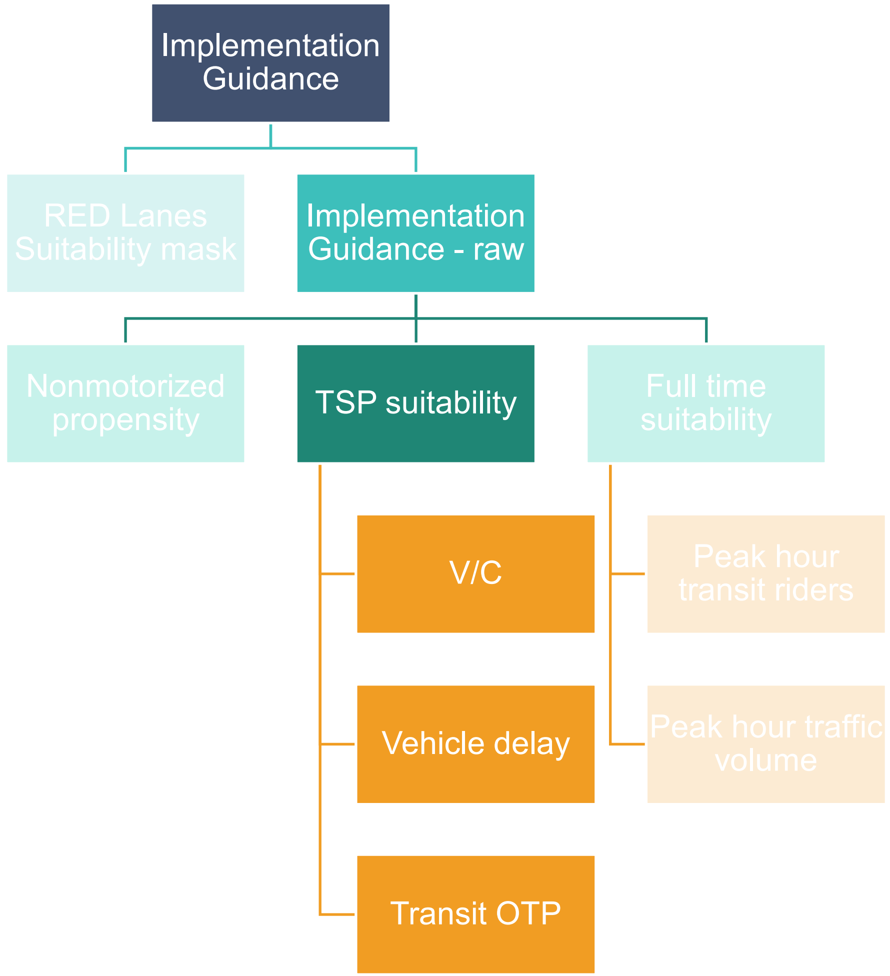
Weight field:JT_LONG

Reference feature class: {inputs_gdb}\UMN_WalkAccess_2014

Analysis method: POLY_TO_RASTER



IMPLEMENTATION GUIDANCE – TSP SUITABILITY



IMPLEMENTATION GUIDANCE – TSP SUITABILITY – V/C RATIO

Remap groups: load from {remaps_dir}/IG_TSP_VC_ratio

Weight field: MAX_PM_VC

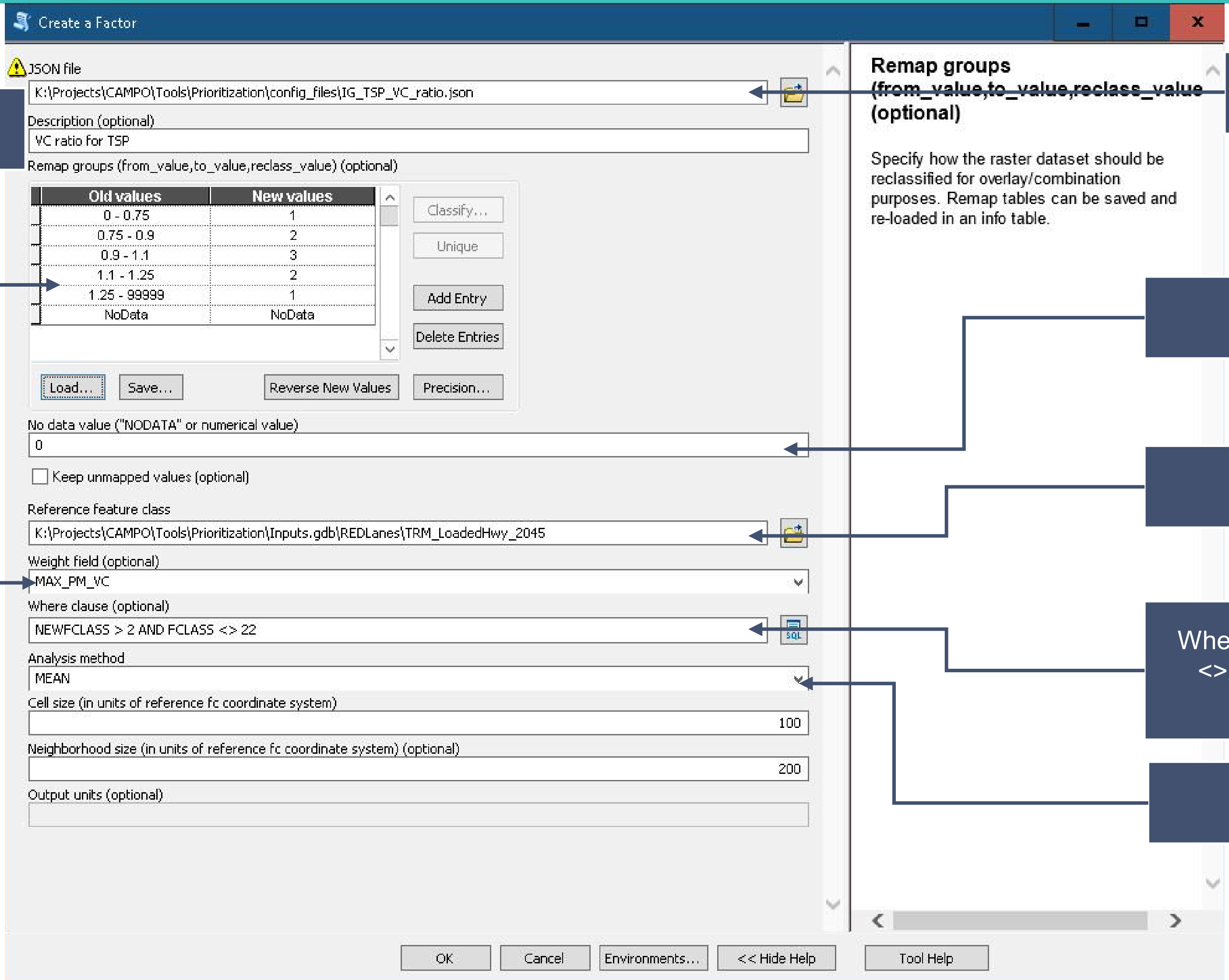
JSON file: {config_dir}\IG_TSP_VC_ratio.json

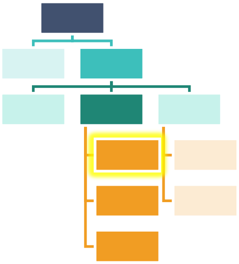
No data value: 0

Reference feature class: {inputs_gdb}\TRM_LoadedHwy_2045

Where clause: NEWFCLASS>2 AND FCLASS <>22 (only include non-limited access/non-tollway facilities)

Analysis method: MEAN

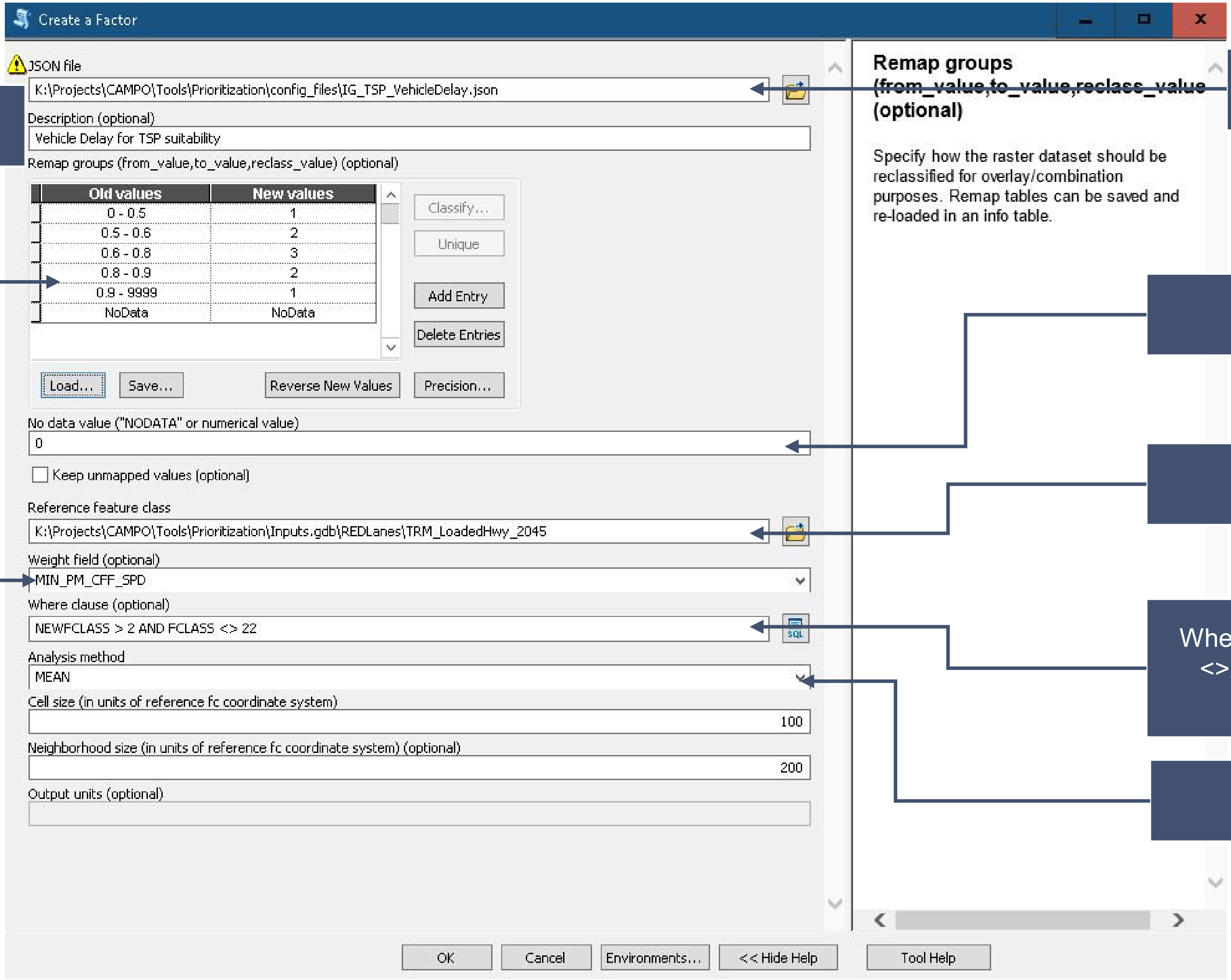




IMPLEMENTATION GUIDANCE – TSP SUITABILITY – VEHICLE DELAY

Remap groups: load from {remaps_dir}/IG_TSP_Vehicle_Delay

Weight field: MIN_PM_CFF_SPD



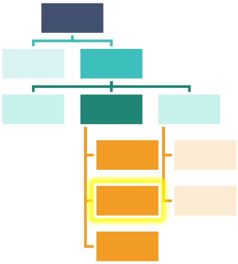
JSON file: {config_dir}\IG_TSP_VehicleDelay.json

No data value: 0

Reference feature class: {inputs_gdb}\TRM_LoadedHwy_2045

Where clause: NEWFCLASS>2 AND FCLASS <>22 (only include non-limited access/non-tollway facilities)

Analysis method: MEAN

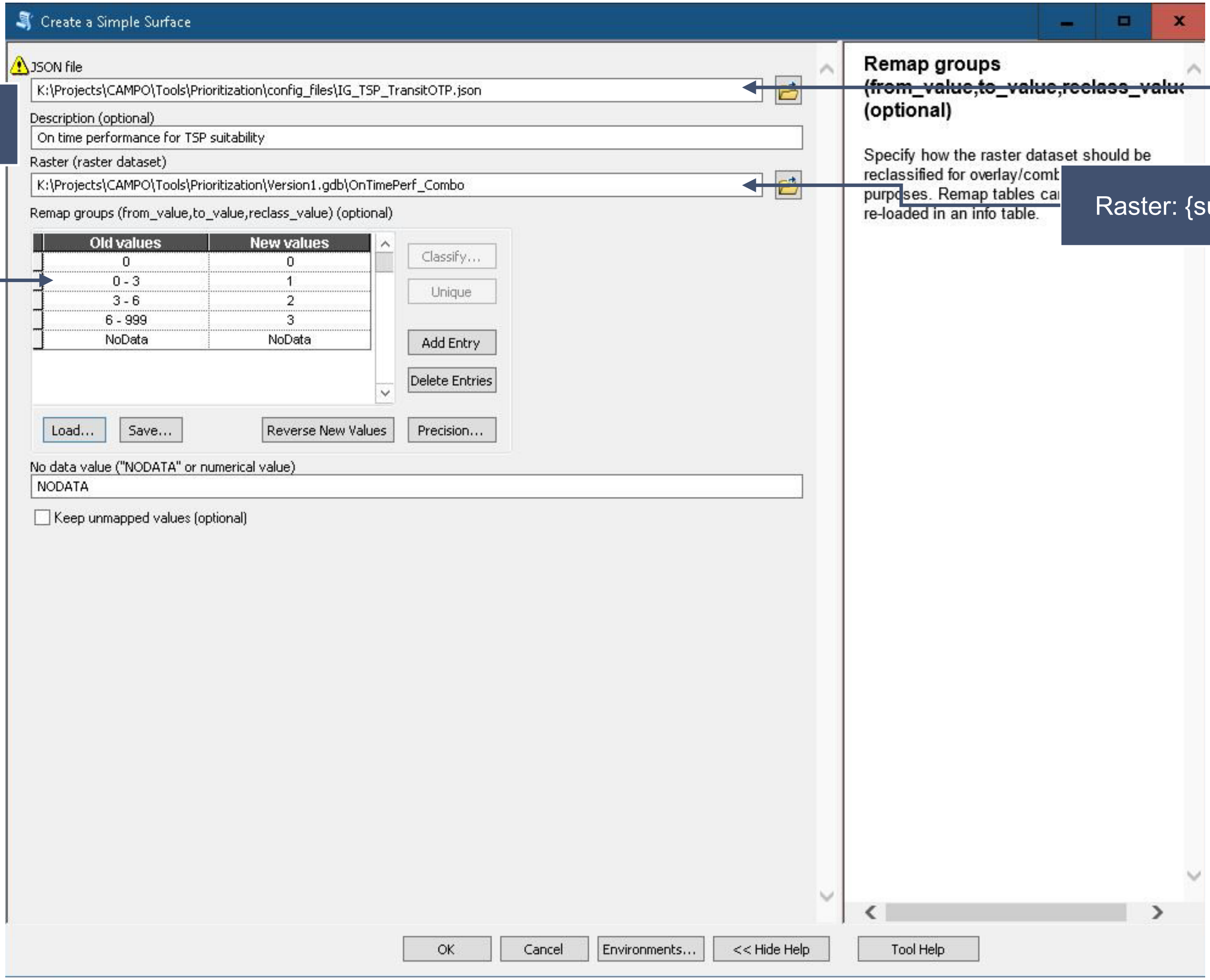


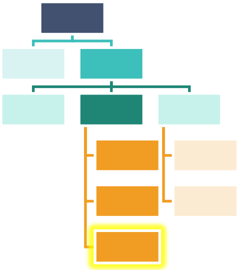
IMPLEMENTATION GUIDANCE – TSP SUITABILITY – TRANSIT OTP

Remap groups: load from {remaps_dir}/IG_TSP_Transit_OTP

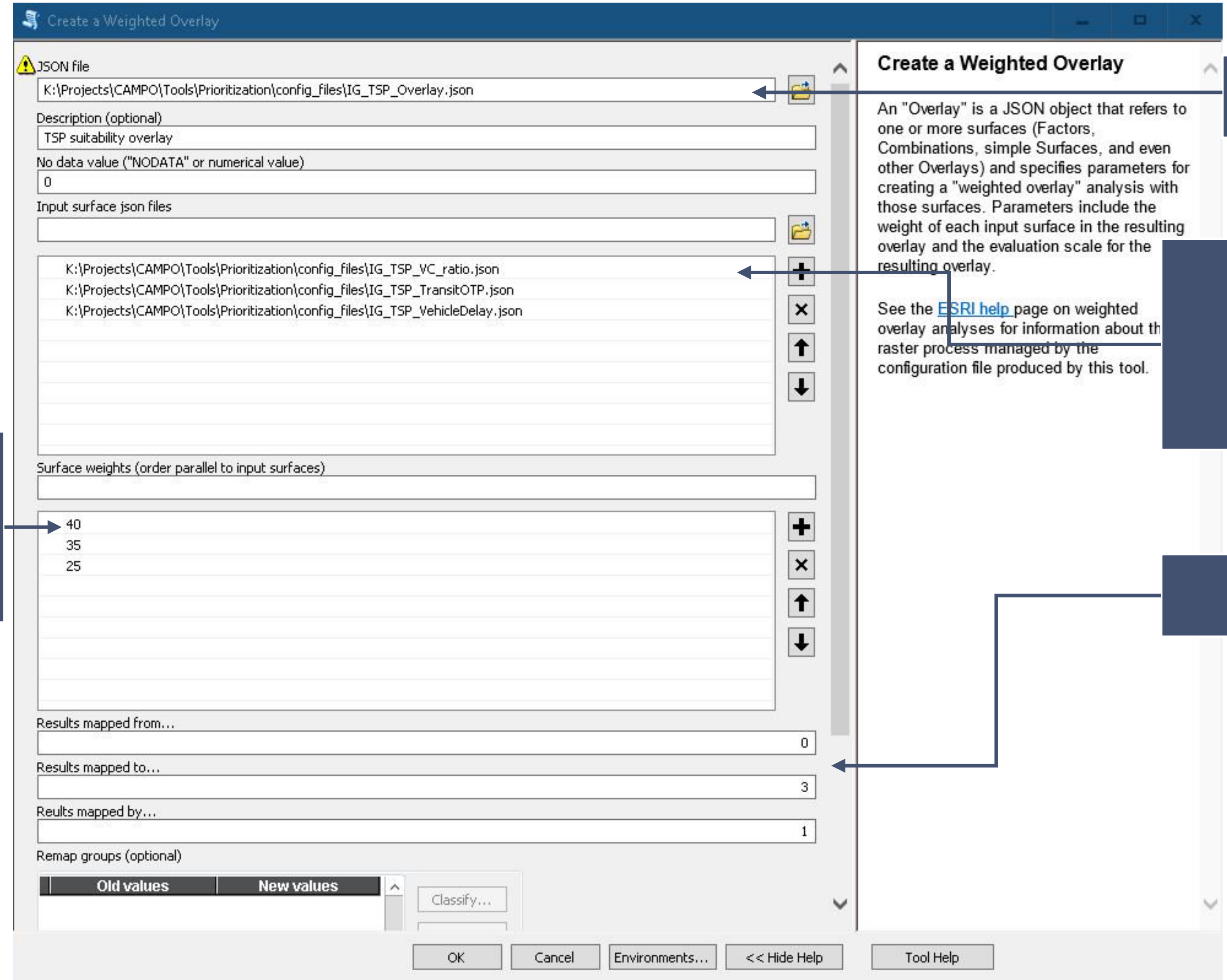
JSON file: {config_dir}\IG_TSP_TransitOTP.json

Raster: {suitability_outputs_gdb}\TransitOps_Overlay





IMPLEMENTATION GUIDANCE – TSP SUITABILITY – OVERLAY

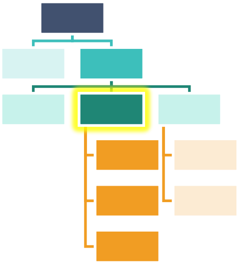


JSON file:
{config_dir}\IG_TSP_Overlay.json

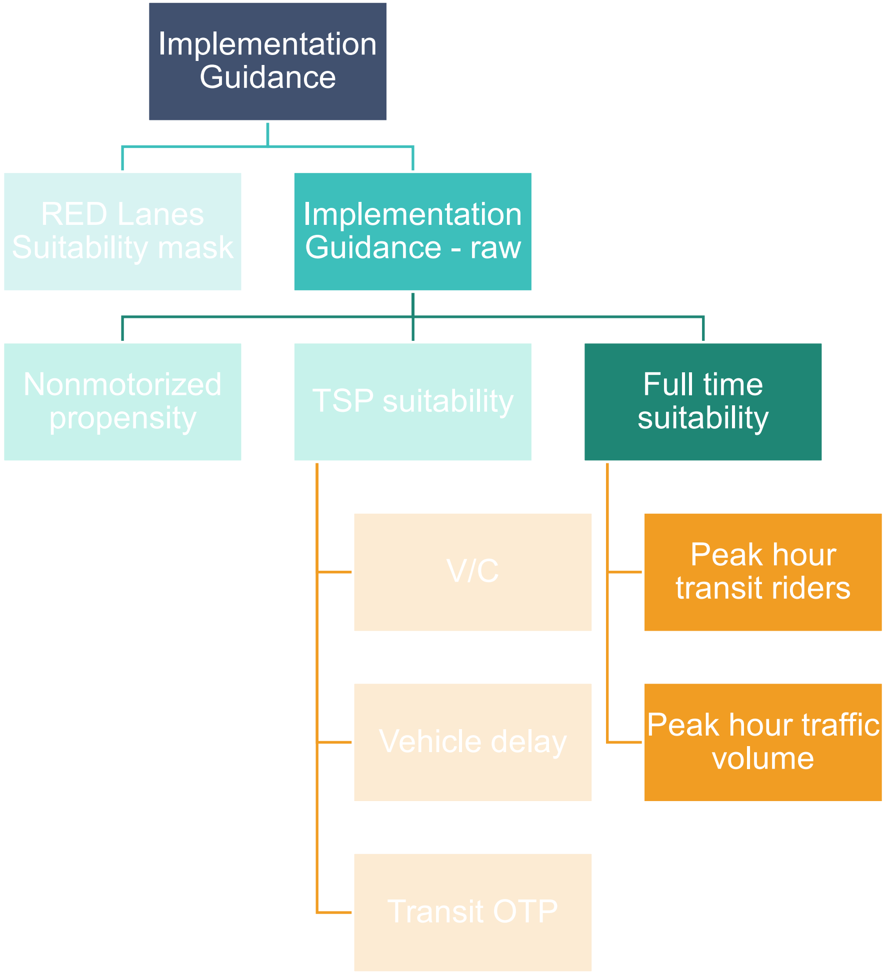
Input surface json files:
{config_dir}\IG_TSP_VC_Ratio.json
{config_dir}\IG_TSP_TransitOTP.json
{config_dir}\IG_TSP_VehicleDelay.json

Weights:
VC Ratio: 40
Transit OTP: 35
Vehicle Delay: 25

Results mapped from/to/by:
Defaults (0/3/1)



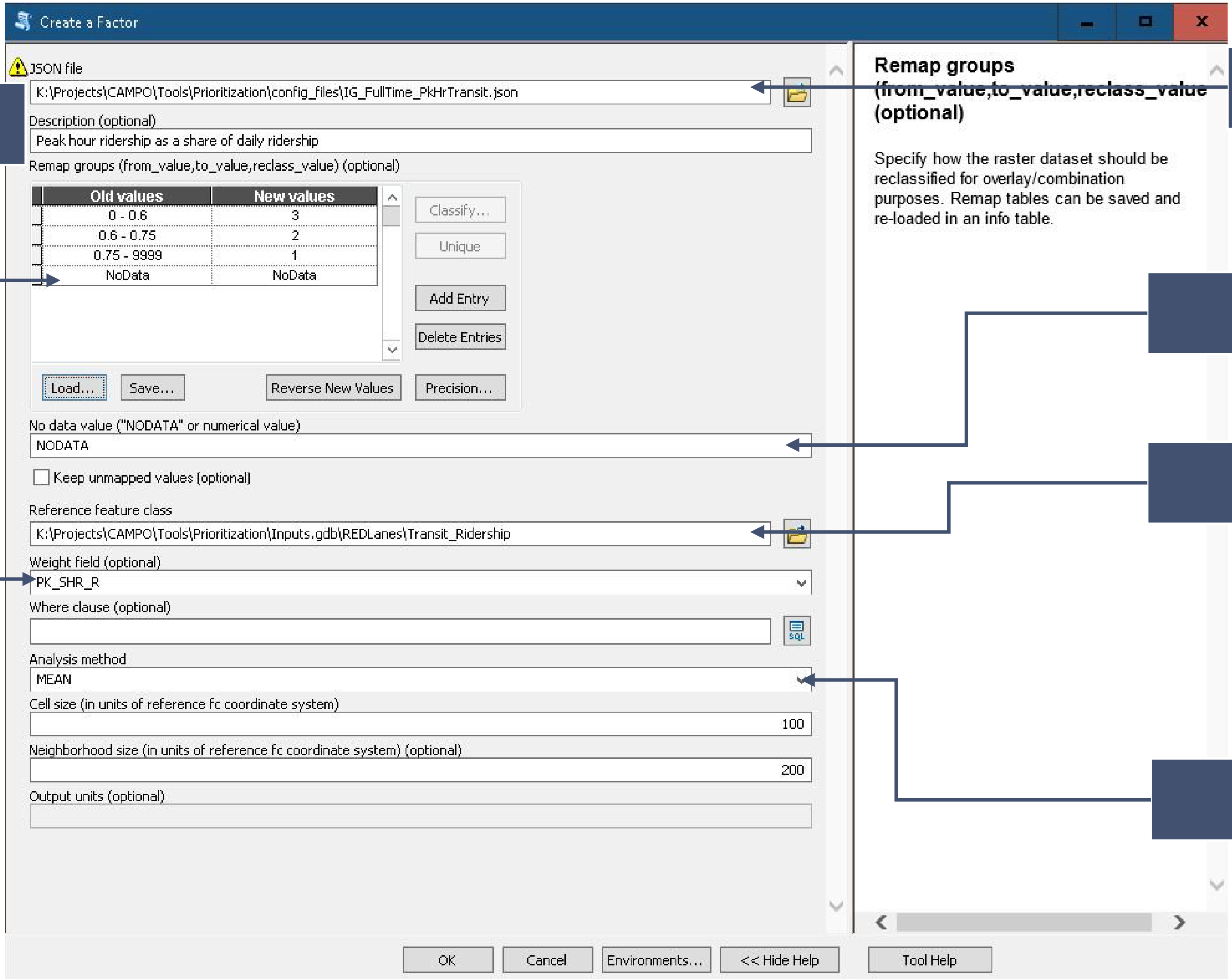
IMPLEMENTATION GUIDANCE – FULL TIME SUITABILITY



IMPLEMENTATION GUIDANCE – FULL TIME SUITABILITY – PEAK RIDERSHIP

Remap groups: load from {remaps_dir}/IG_FullTime_PHTransit

Weight field: PK_SHR_R

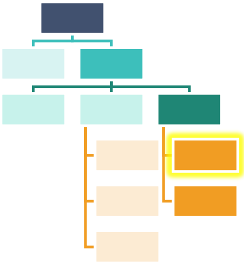


JSON file: {config_dir}\IG_FullTime_PkHrTransit.json

No data value: NODATA

Reference feature class: {inputs_gdb}\Transit_Ridership

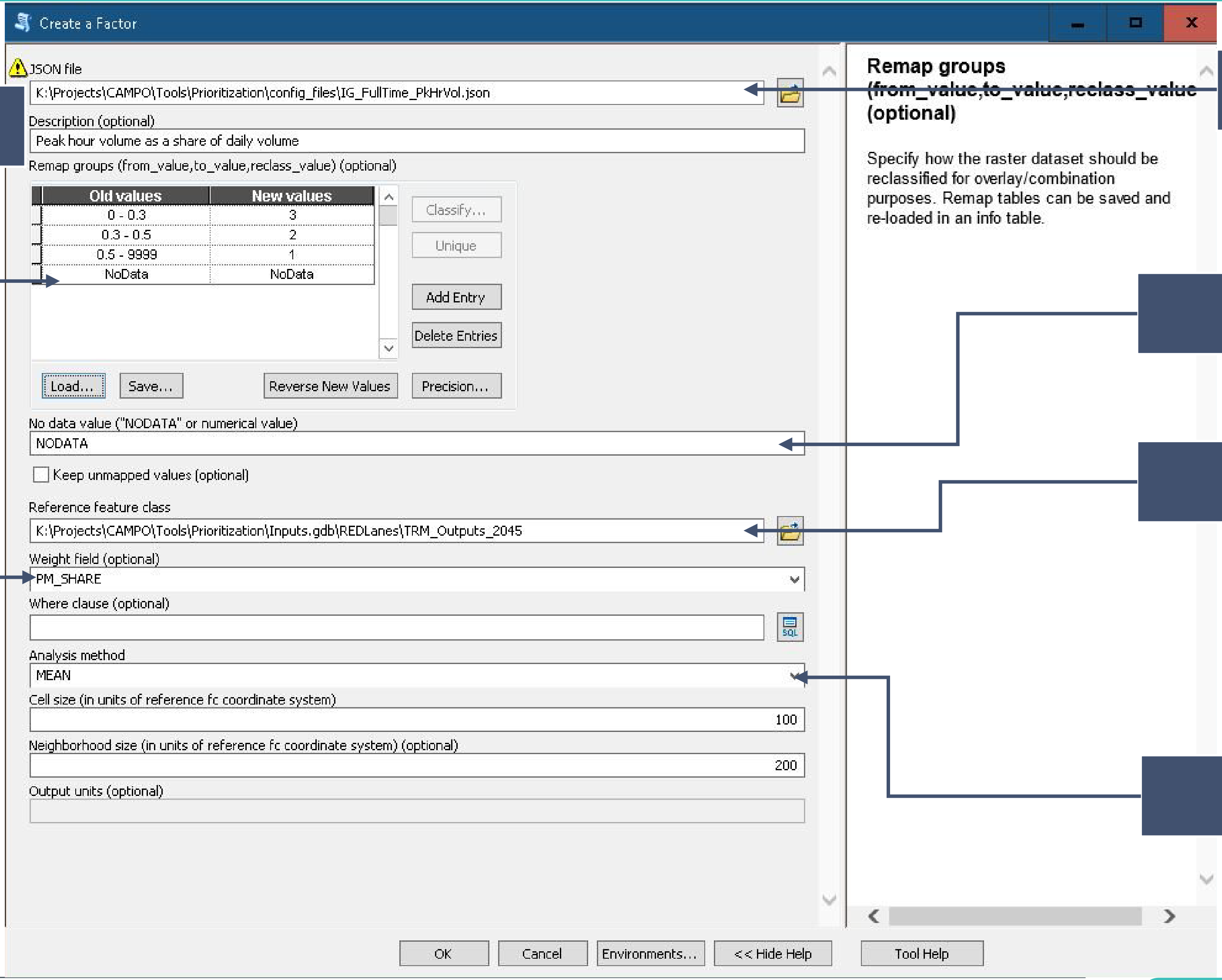
Analysis method: MEAN



IMPLEMENTATION GUIDANCE – FULL TIME SUITABILITY – PEAK VOLUME

Remap groups: load from {remaps_dir}/IG_FullTime_PHVol

Weight field: PM_SHARE

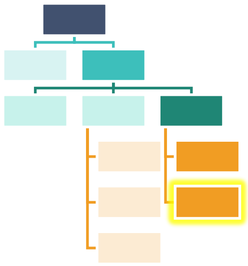


JSON file: {config_dir}\IG_FullTime_PkHrVol.json

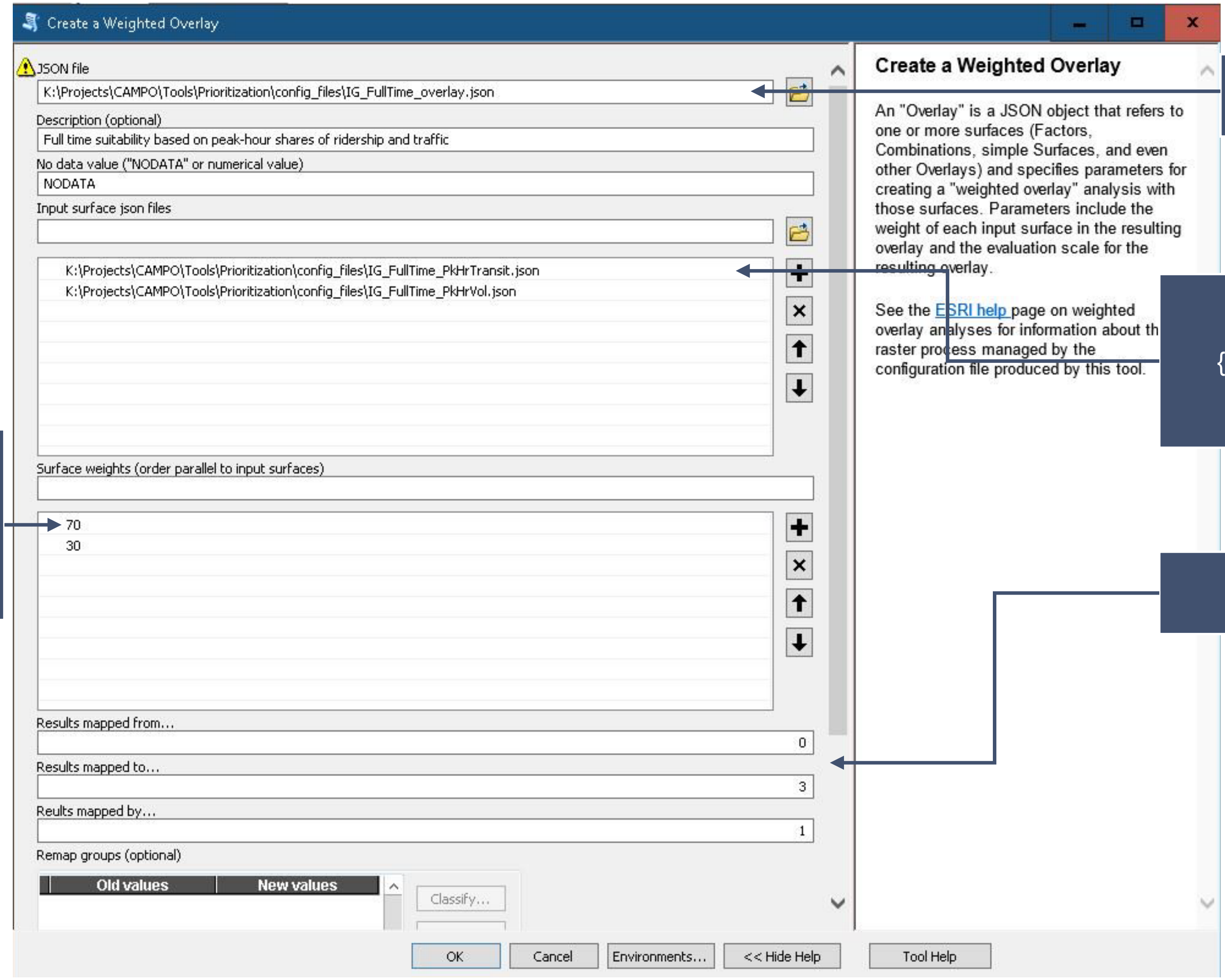
No data value: NODATA

Reference feature class: {inputs_gdb}\TRM_Outputs_2045

Analysis method: MEAN



IMPLEMENTATION GUIDANCE – FULL TIME SUITABILITY – OVERLAY

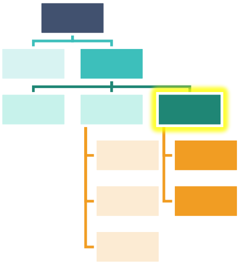


JSON file:
{config_dir}\IG_FullTime_Overlay.json

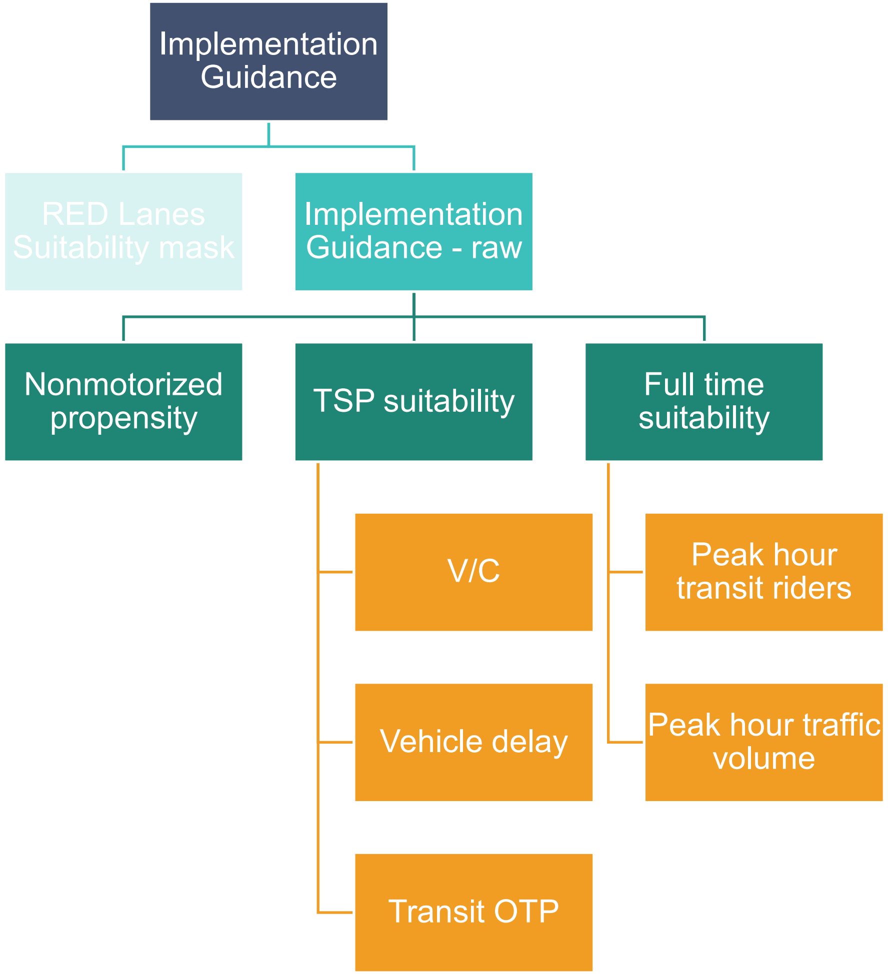
Input surface json files:
{config_dir}\IG_FullTime_PkHrTransit.json
{config_dir}\IG_FullTime_PkHrVol.json

Weights:
Peak Hour Ridership Share: 70
Peak Hour Volume Share: 30

Results mapped from/to/by:
Defaults (0/3/1)



IMPLEMENTATION GUIDANCE – RAW COMBO

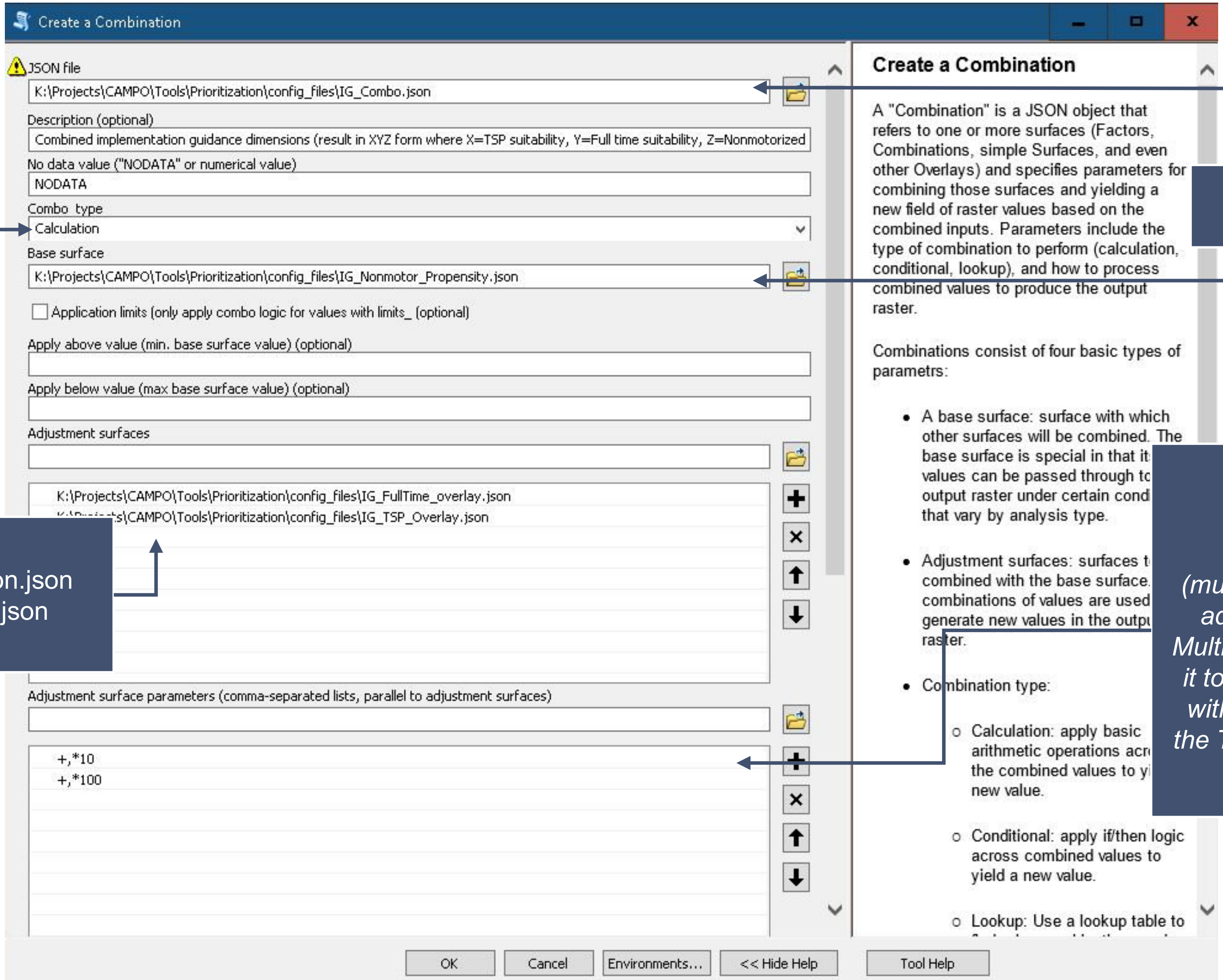


IMPLEMENTATION GUIDANCE – RAW COMBO

Combo type: Calculation

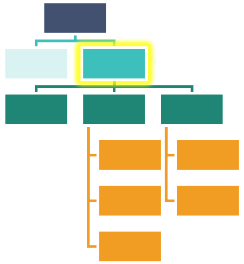
JSON file: {config_dir}\IG_Combo.json

Base surface:
{config_dir}\IG_Nonmotor_Propensity.json

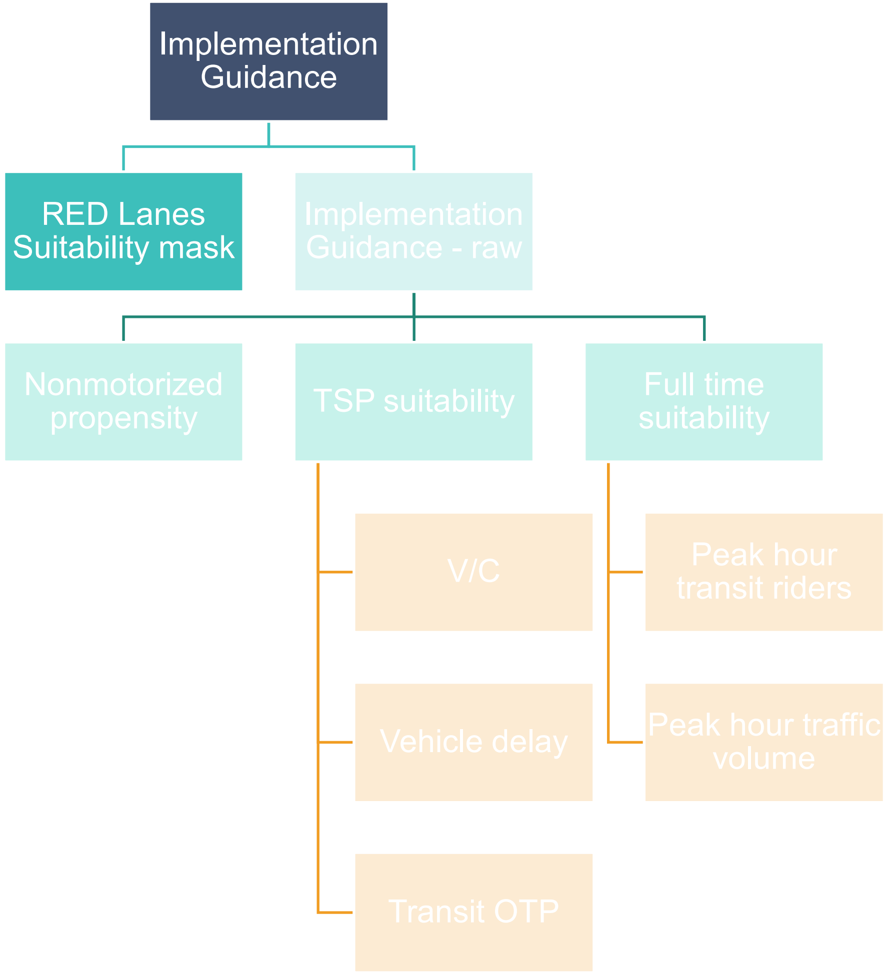


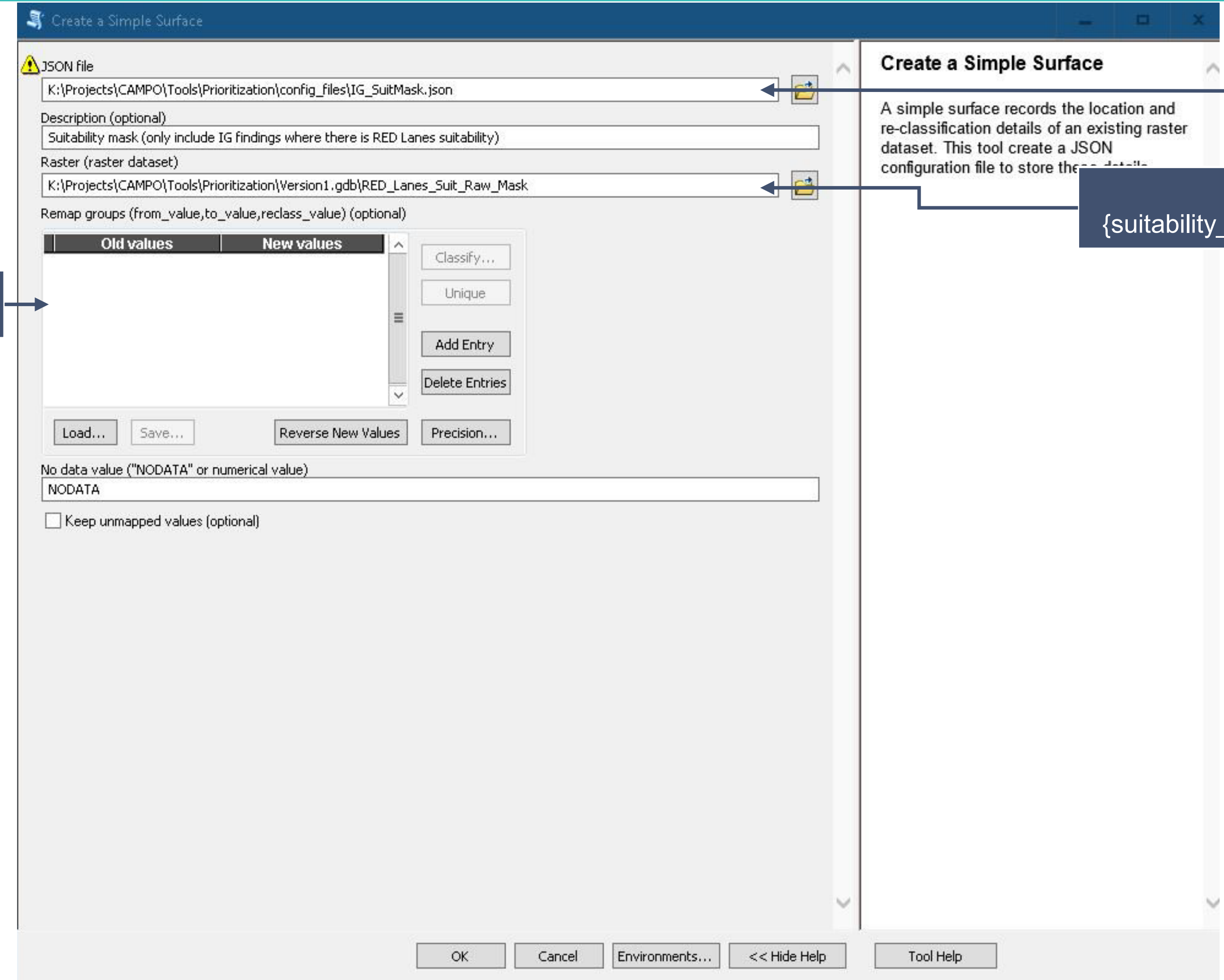
Adjustment surface parameters:
+,*10
+,*100
(multiply the full-time suitability value by 10 and add it to the nonmotorized propensity value; Multiple the TSP suitability value by 100 and add it to the previous value – this produces a raster with three-digit output values, XYZ, where X is the TSP score and Y is the full-time score, and Z is the nonmotorized propensity score)

Adjustment surfaces:
{config_dir}\IG_FullTime_Overlay.json.json
{config_dir}\IG_TSP_Overlay.json.json



IMPLEMENTATION GUIDANCE – MASKING

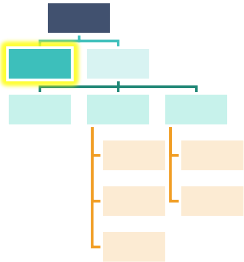




JSON file: {config_dir}\IG_SuitMask.json

Raster: {suitability_outputs_gdb}\RED_Lanes_Suit_Raw_Mask

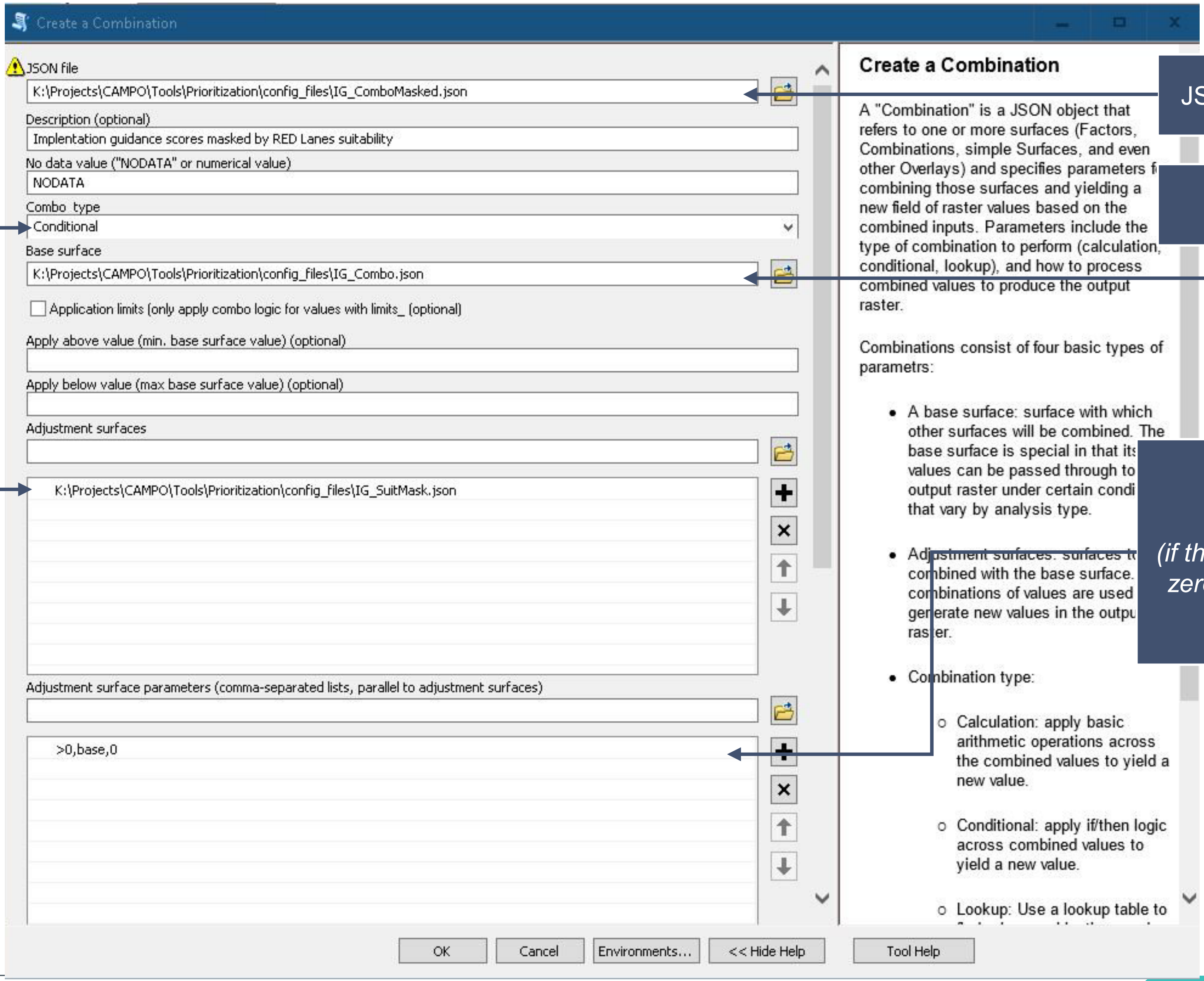
Remap groups: (none)



IMPLEMENTATION GUIDANCE – ADDING THE SUITABILITY MASK

Combo type: Conditional

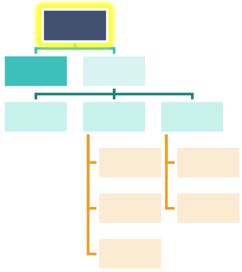
Adjustment surfaces: {config_dir}\IG_SuitMask.json



JSON file: {config_dir}\IG_ComboMasked.json

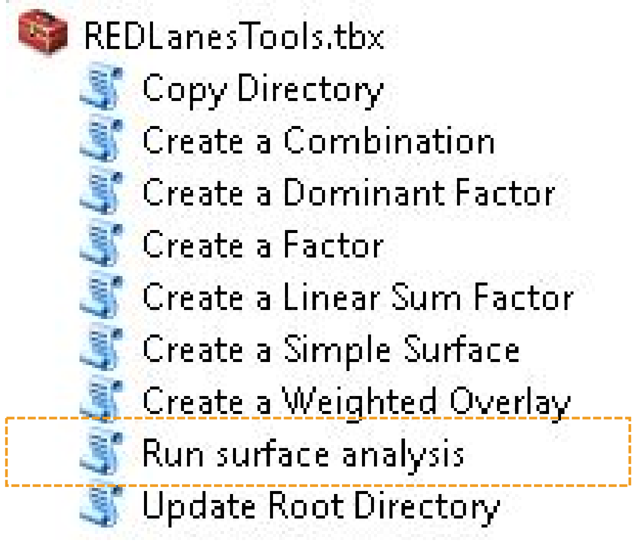
Base surface: {config_dir}\IG_Combo.json

Adjustment surface parameters:
>0,base,0
(if the RED Lanes suitability score is greater than zero keep the IG combo score, else set the cell value to zero)



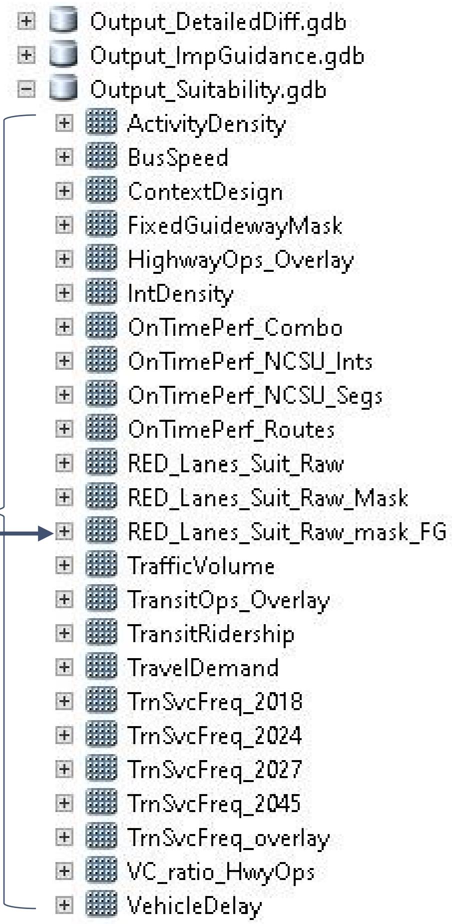
USING THE "RUN SURFACE ANLAYSIS" TOOL

- Use the "**Run Surface Analysis**" tool to create the resulting raster for a specified surface configuration (.json) file as well as all prerequisite files. Warning! All existing files in the output geodatabase are deleted when this tool is run.
- **Three** runs of the "Run Surface Analysis" tool are made for the RED Lanes evaluation process:
    1. "RED_Lanes_Suit_Raw_Mask_FG.json" - Calculates raw suitability and applies the transit service and fixed-guideway masks.
    2. "DD_ComboMasked.json" – Calculates and combines detailed differentiator variables and applies the transit service mask.
    3. "IG_ComboMasked.json" – Calculates and combines implementation guidance variables and applies the transit service mask.



USING THE “RUN SURFACE ANLAYSIS” TOOL

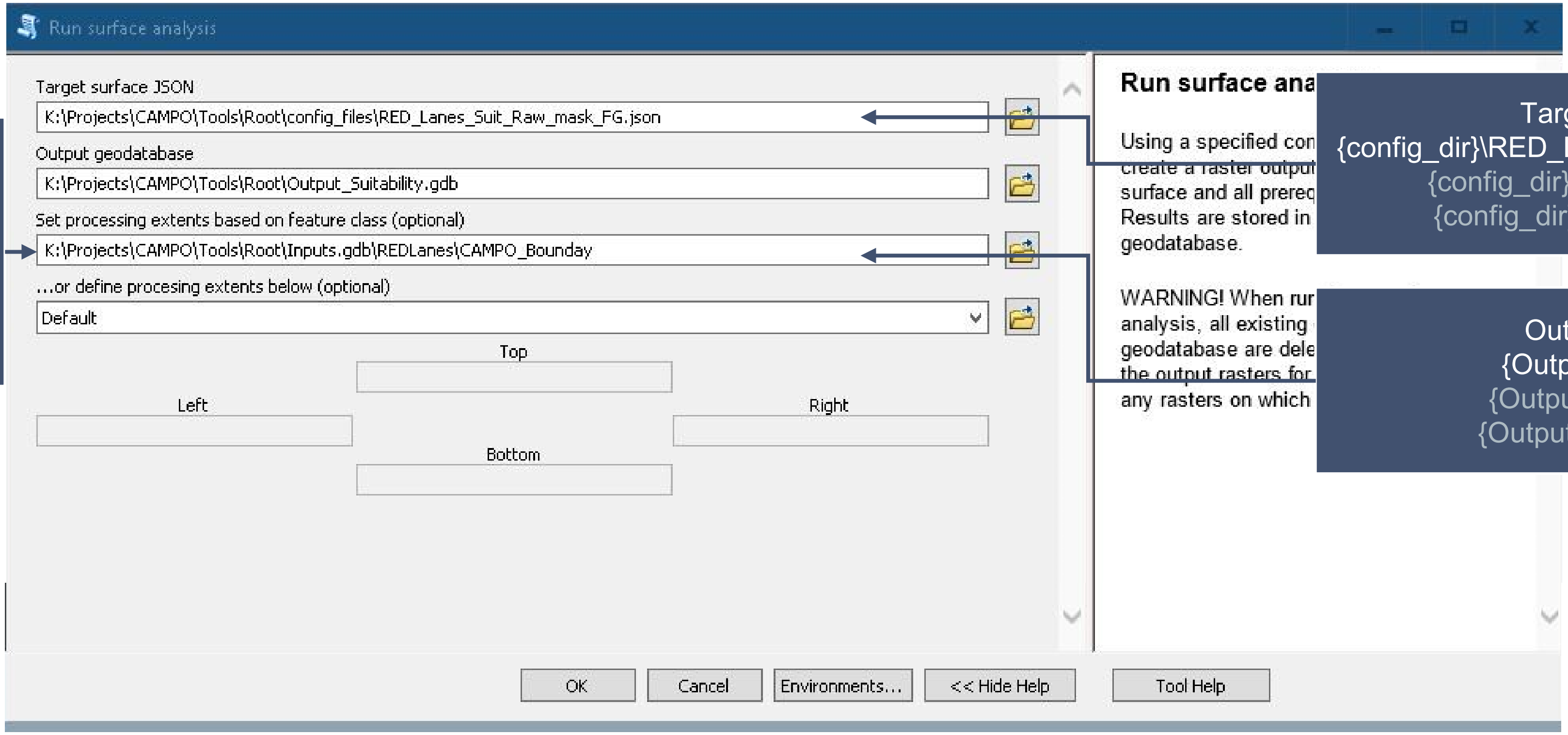
- Select a surface json file as the “final” output. This surface’s resulting raster will be produced in the output workspace.
- All pre-requisite surfaces will be analyzed and resulting rasters produced in the output workspace.
- Spatial analyst extension must be installed and licensed for this tool to run successfully.
- Optional: set processing extents to define a consistent frame of reference for all surfaces to be produced
    - This is recommended as different input datasets have different default processing extents.
    - The CAMPO boundary polygon in the Inputs geodatabase is provided for precisely this application.



USING THE "RUN SURFACE ANLAYSIS" TOOL

Set processing extents:
{input_gdb}\CAMPO_Boundary

(Extents can all be set manually in the field below, but this is more complex than simply pointing to the boundary file.)



Target surface JSON:
{config_dir}\RED_Lanes_Suit_Raw_mask_FG.json
{config_dir}\DD_ComboMasked.json
{config_dir}\IG_ComboMasked.json

Output geodatabase:
{Outputs_Suitability.gdb}
{Outputs_DetailedDiff.gdb}
{Outputs_ImpGuidance.gdb}

Warning! All existing files in the output geodatabase are deleted when this tool is run.

AUTOMATED SEGMENTATION USING R

- The RED Lanes evaluation process outputs are in raster format (100-foot grid cells).
- To generate segment-level scores from the raster datasets, a spatial analytics script has been developed in R.
  - R provides spatial analysis capabilities and conveniences that ArcGIS either does not offer or requires additional licenses beyond Spatial Analyst.
  - The script is simple to run in R Studio.

AUTOMATED SEGMENTATION USING R

- **To download R for the first time**, visit http://archive.linux.duke.edu/cran/.
  - For Windows, select "Download R for Windows", then "install R for the first time", then "Download R for Windows". Once the installer is downloaded, open it and complete the setup wizard, keeping all defaults.
  - For Mac, select "Download R for (Mac) OS X", then the download link for the .pkg file for the latest release of R. Once the installer is downloaded, open it and complete the setup wizard, keeping all defaults.

- **Once R is installed,** visit https://rstudio.com/products/rstudio/download/ to download RStudio.
  - Select "Download" beneath RStudio Desktop, then under "All Installers" on the next page, select the download link for your OS. Once the installer is downloaded, open it and complete the setup wizard, keeping all defaults.

AUTOMATED SEGMENTATION USING R

- Once R and RStudio are installed, open each of the provided files in RStudio. They are numbered according to the order in which they should be completed (00 through 06)
- Go to the "00_Dependencies" script. At the top right of Script window (top left panel), click the "Source" button. Your first time running these scripts on a new machine, you will be prompted to allow package installs – follow the prompts on the screen to complete any necessary installs.
- Once "Complete" is printed in the RStudio console (bottom left panel), continue to the "01_Intersect" script. Click "Source"; this time, you will be prompted for a few function inputs – enter them according to the on-screen instructions.
- Once "Complete" is printed in the console, move onto "02_Clip". Again, Click "Source", and again follow the prompts. Once "Complete" is printed, continue to the next script.
- Continue the above pattern of Sourcing the script, providing inputs, waiting for "Complete", and moving to the next script until the final script "06_Enrich" is completed. At this point, segmentation is finished, and the final output will be at the write directory you specified as an input to "06_Enrich".

AUTOMATED SEGMENTATION USING R

- Notes on processing the scripts:
  - The NCDOT street routes should be saved as ".shp". The suitability, detailed differentiators, and implementation guidance rasters should be saved as ".tif"
  - When a read or write directory is requested as a function input, we recommend using "copy as path" functionality (shift-right click on the folder, then select "copy as path") for inputting the directory path. The scripts are designed to work best with paths input using this method.
  - We **highly recommend** writing all outputs to the same directory. We also recommend placing the NCDOT street routes shapefile, suitability raster, and detailed differentiators/implementation guidance rasters in this directory for the same reason. **If you do this, you can enter the same path every time a directory is requested as an input, read or write!**
  - The read/write directories **cannot** be geodatabases. R does not support writing to geodatabases; if you'd like your outputs in a geodatabase, please do this manually upon completion of the entire process.
  - Outputs of each script will automatically be saved with a file name matching that of the script it produces for ease of process

MANUAL QA/QC

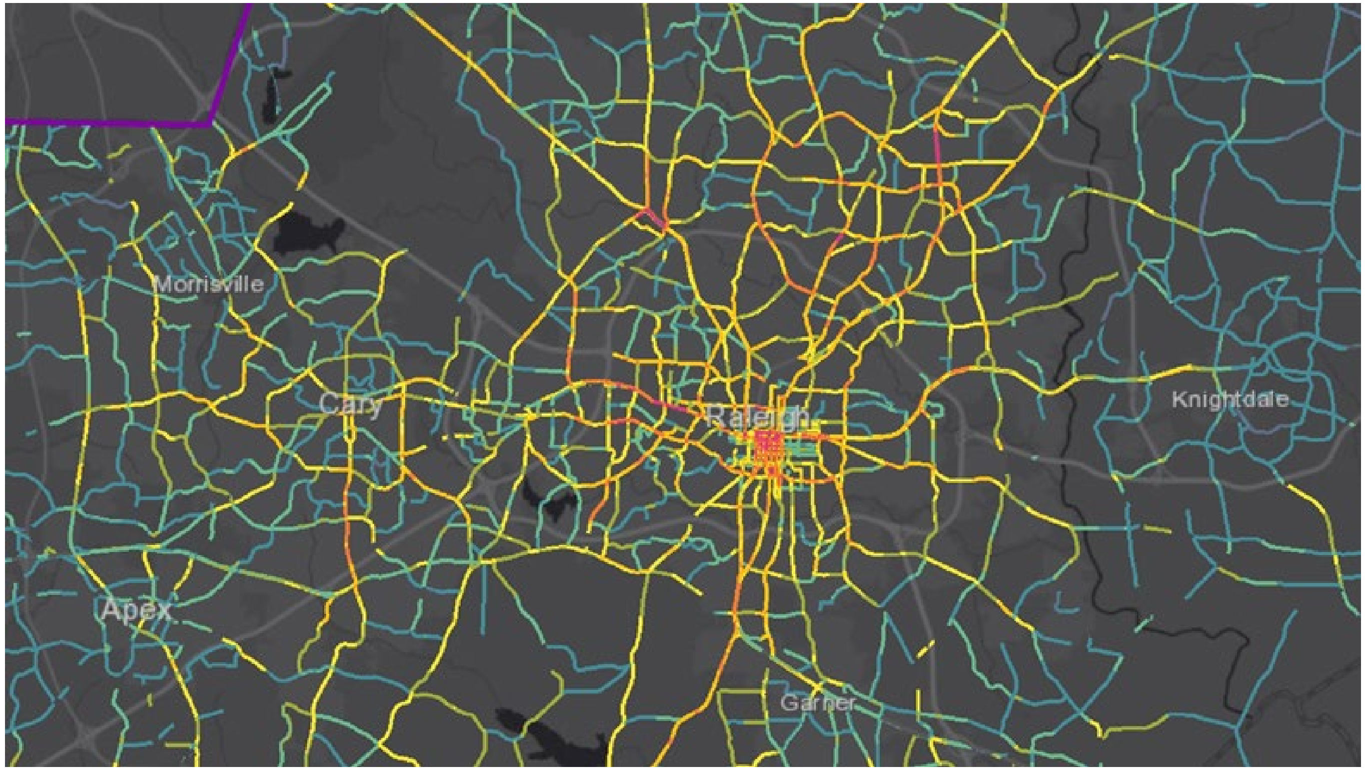
- Compare segment outputs to raw suitability rasters
- Manually code and overwrite features/attributes for missing segments.

4 SPATIAL ANALYST CONCEPTS

SPATIAL ANALYST - OVERVIEW

From ArcGIS.com…

"The ArcGIS Spatial Analyst extension provides a rich set of spatial analysis and modeling tools for both raster (cell-based) and feature (vector) data."



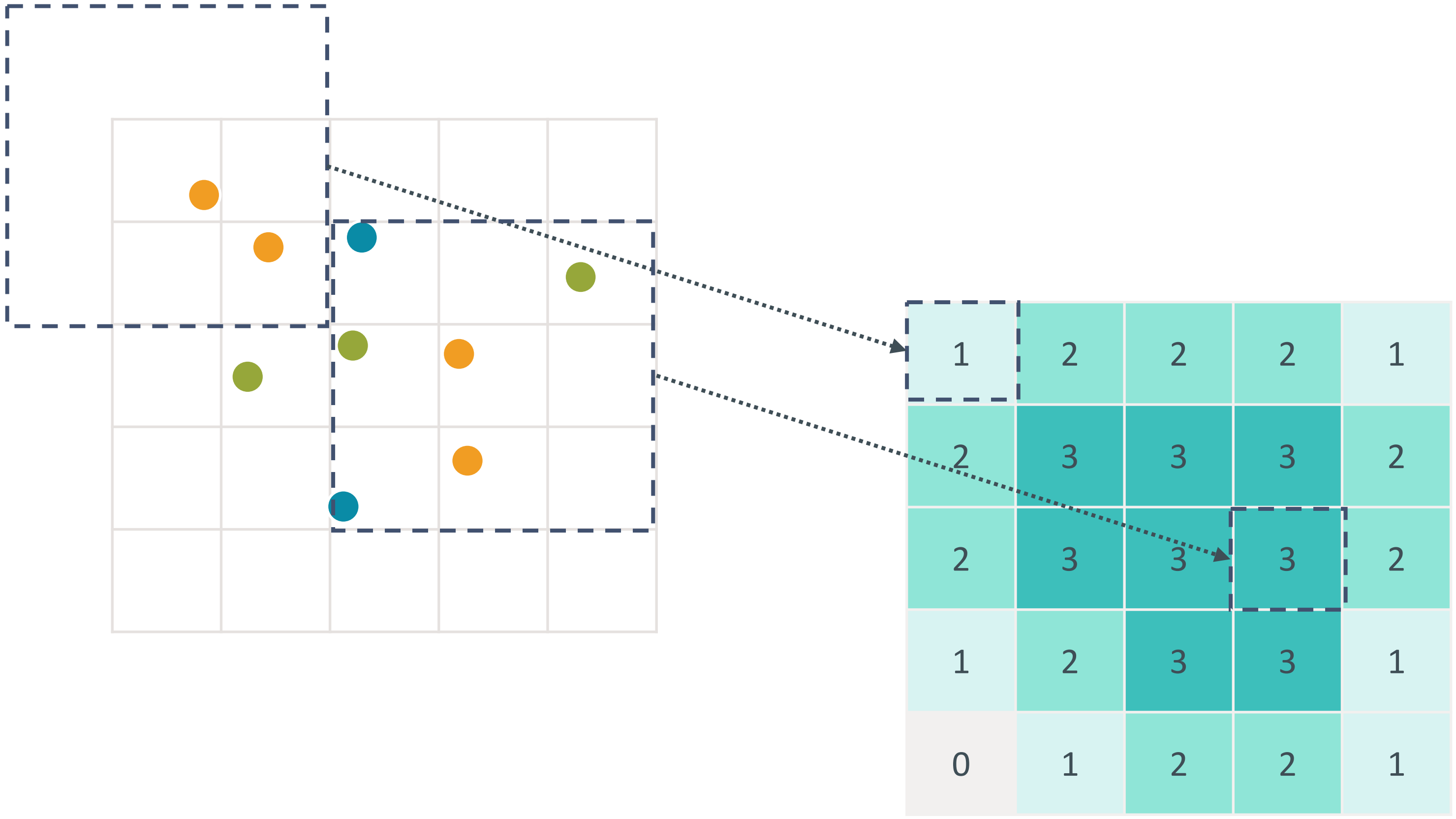
SPATIAL ANALYST - OVERVIEW

Tools for analyzing spatial patterns based on raster and vector data

- Many useful capabilities for operationalizing the concepts and measures identified for RED Lanes suitability
  - Create raster datasets from vector data (points, lines, polygons)
  - Process raster datasets
    - Weighted overlay analysis
    - Combine and calculate values in the same place or in the vicinity

USEFUL CAPABILITIES – CREATE RASTERS FROM VECTOR DATA

Translate vector data (points, lines, polygons) into rasters



Example: how many distinct colors are there within the “floating zone”?

- Vector data = features in a feature class or shape file *(dots in illustration)*
- Raster = network of equally-sized cells *(grids in illustration)*
- Floating zone or “neighborhood” in arcpy terminology = area of specified size and shape *(dashed outlines in illustration)*
    - Circle
    - Square
    - Annulus (doughnut)
    - Wedge

USEFUL CAPABILITIES – OVERLAY RASTERS

Get the weighted average of cells representing the same location.

- Raster 1 and raster 2 define the same area using cells of the same size
- Raster 1 is assigned a weight of 30%; raster 2 is assigned a weight of 70%
- The weighted overlay yields raster 3
- Consider the outlined cell in each raster as an example:
    - (2 * 0.3) + (1 * 0.7) = (0.6 + 0.7) = 1.3
    - The overlay analysis will return the nearest integer, so the value in raster 3 is 1

Raster 1

1	2	2	4	4
1	2	3	3	4
2	2	3	3	4
1	$\boxed{2}$	3	3	4
1	1	2	3	3

+

Raster 2

2	3	4	5	5
2	2	3	4	5
1	1	3	4	4
1	$\boxed{1}$	2	3	4
1	1	2	3	3

→

Raster 3

2	3	3	5	5
2	2	3	4	5
1	1	3	4	4
1	$\boxed{1}$	2	3	4
1	1	2	3	3

USEFUL CAPABILITIES – COMBINE RASTERS

Calculate a new value based on the values in two raster datasets

- Raster 1 and raster 2 define the same area using cells of the same size
- If the value in raster 1 is 3 or greater and the value in raster 2 is 1, calculate a new value of 9
- Otherwise, retain the value from raster 1
- The combination yields raster 3

Raster 1

1	2	2	4	4
1	2	3	3	4
2	2	3	3	4
1	2	3	3	4
1	1	2	3	3

Raster 2

0	0	0	1	1
0	1	1	1	0
0	0	1	1	1
0	1	0	1	1
0	0	1	1	0

Raster 3

1	2	2	9	9
1	2	9	9	4
2	2	9	9	9
1	2	3	9	9
1	1	2	9	3

ADDITIONAL NOTES ON SPATIAL ANALYST

STRENGTHS

- Faster, easier to implement, and simpler to construct “surfaces” representing all locations within a study area than vector-based or network-based analysis methods.
- Account for areawide typical conditions using consistent cell size and neighborhood size (floating zone) definitions

LIMITATIONS

- Can be unpredictable when working with source data in inconsistent spatial reference systems
  - Best practice: ensure that all input data are projected into the same spatial reference
- Account for areawide conditions without regard for barriers, such as waterways or major highways
- Most geo-processors yield integer rasters (floating point rasters can be created but can be unwieldy in terms of designing a process around these)
  - Potential loss of precision for any given step (review “raster overlay” example illustration above)

5 PYTHON TOOLKIT DOCUMENTATION

HIERARCHICAL OVERLAY AND COMBINATION SCRIPTS

- Object-oriented approach
  - Defines “objects” that define how to develop and process raster data sets for analysis in ArcGIS’s Spatial Analyst extension
  - Objects have “attributes”: information stored in the object
  - Objects have “methods”: functions that facilitate or automate a variety of workflows
- Utilizes ArcGIS’s (v. 10.2.1) arcpy library to automate geo-processing steps
  - Also numpy (v. 1.13.3), which is installed alongside arcpy
  - Also a couple of standard Python libraries
    - json
    - copy
    - Ast
    - OrderedDict (from collections)
  - Scripts developed in Python v. 2.7.12

SCRIPT OBJECTS

- Surface (the basic building block)
- Sub-classes of Surface
  - Factor
    - DominantFactor
    - LinearSum
  - Overlay
  - Combination
    - ConditionalCombination
    - CalculationCombination
    - LookupCombination
- HierarchyManager

SURFACE CLASS

SURFACE CLASS

<u>Primary purpose: store meta-data about a raster dataset and how to re-classify values to facilitate geo-processing</u>

- Attributes:
  - workspace, raster, and path: Where is the raster dataset that is the focus of the Surface object?
  - no_data_value: How to treat "NO DATA" (missing) values in the raster dataset when processing
  - remap_groups, remap: How to reclassify values (arcpy.sa.RemapRange object)
  - Status flags (processed, reprocess):
    - Has this surface already been processed?
    - Does it need to be re-processed (based on user actions)?
- Methods:
  - setRaster, setWorkspace: Set raster location (workspace or file)
  - addRemapGroup, removeRemapGroup, updateRemapGroup: Manage reclassification preferences

SURFACE CLASS – RECLASSIFICATION PROTOCOLS

31	31	48	46	55
21	32	33	45	46
20	21	33	33	45
10	22	24	32	31
ND	18	24	33	34

REMAP:

Raster value	Reclass value
10-19	1
20-29	2
30-39	3
40-49	4
50-59	5
60-99	6

NO DATA (ND) = 1

3	3	4	4	5
2	3	3	4	4
2	2	3	3	4
1	2	2	3	3
1	1	2	3	3

FACTOR CLASS

FACTOR CLASS (SUBCLASS OF SURFACE)

Primary purpose: create a Surface object from vector data

- Major attributes:
  - reference_fc: What feature class (vector data) will be used to create the surface?
  - field: What field in the feature class above will be used to create the surface? (optional)
  - analysis_method: What analysis method will be used to create the surface (options depend on feature class type – point, line, or polygon)?
    - Density, kernel density, sum/length, min, max, mean, median, majority, minority, range, standard deviation, variety
  - units: Units to use for raster processing
  - cell_size: Output cell size
  - neighborhood_size: Search radius for the floating zone
  - sr: Spatial reference system
  - where_clause: Where clause (defining criteria for features in the feature class used to create the surface)
- Also inherits attributes from the Surface class

FACTOR CLASS (SUBCLASS OF SURFACE)

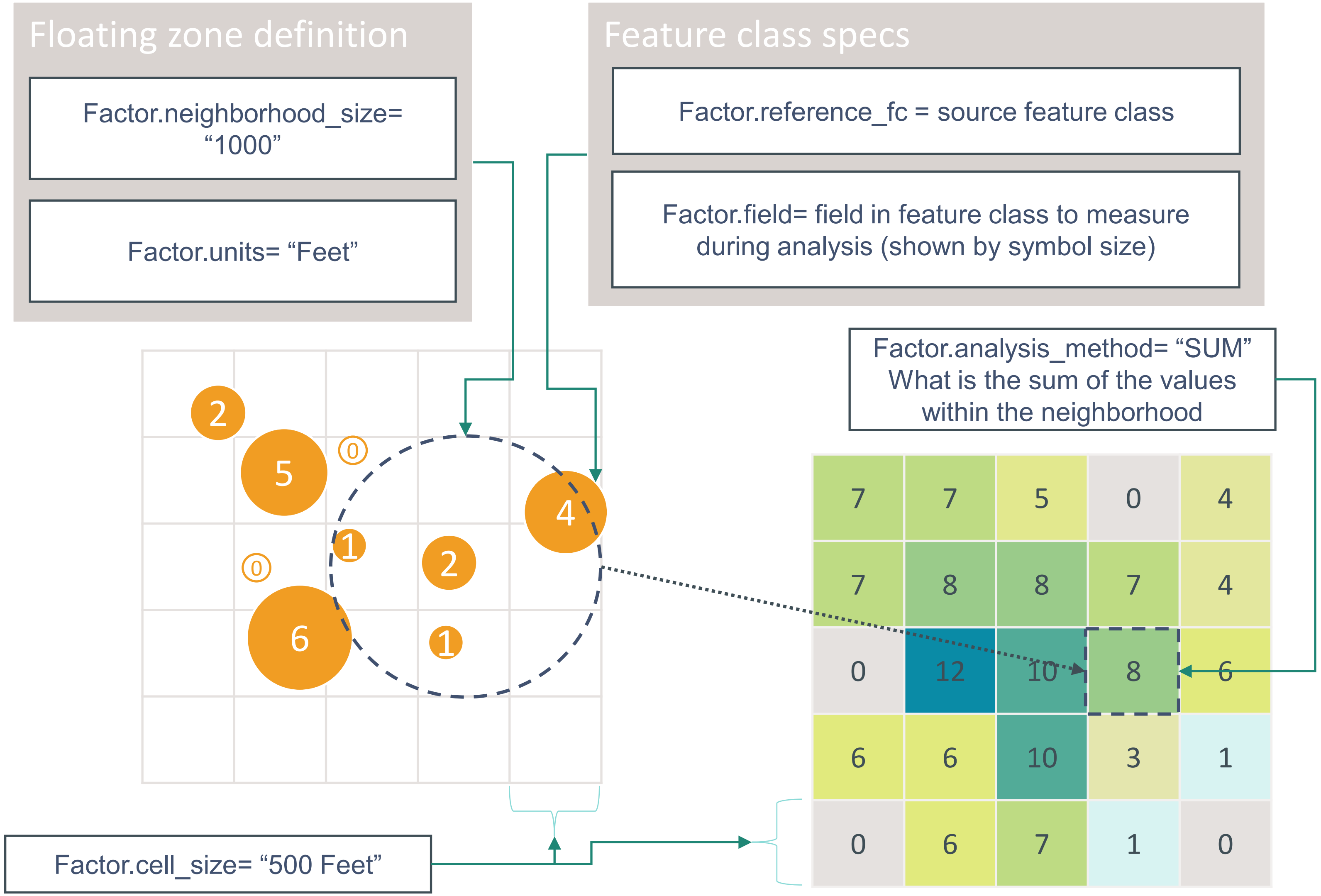
Primary purpose: create a Surface object from vector data

- Major methods:
  - rasterize: based on the attributes, create a raster from the vector data in the referenced feature class
- Also inherits methods of the Surface class

FACTOR CLASS (SUBCLASS OF SURFACE) – RASTERIZE METHOD

The attributes of the Factor class define how a raster (Surface) will be developed from vector data (reference_fc). Resulting raster values are based on applying the chosen analysis method to evaluate features within the floating zone (neighborhood_size, units), weighted by the chosen field in the reference feature class. The resulting raster will have square cells of the size specified by the cell_size attribute.

The creation of the resulting raster is facilitated by the rasterize method.



DOMINANT FACTOR CLASS

DOMINANT FACTOR CLASS (SUBCLASS OF FACTOR)

Primary purpose: create a Surface object by creating a temporary series of Factor objects and choosing the largest (or smallest) among them

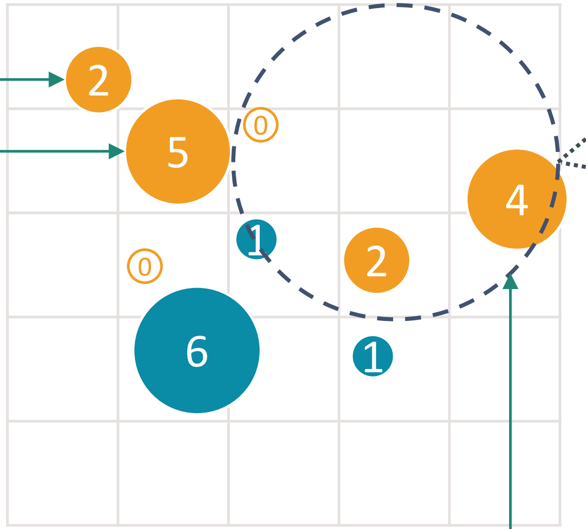
- Major attributes:
  - value_field: Groups features within the reference_fc attribute (inherited from Factor class) into discrete categories
  - weight_field: What field in reference_fc will be used to create each temporary Factor object?
- Major methods:
  - dominantValue: Use the attributes named above to determine which group of features is the most (or least) prevalent
- Also inherits attributes and methods from the Factor and Surface classes
- Example of use: “dominant land use” – what land use category (value_field) is most common within the floating zone area based on the total building area (weight_field) in the floating zone for each distinct use code?

DOMINANT FACTOR (SUBCLASS OF FACTOR)

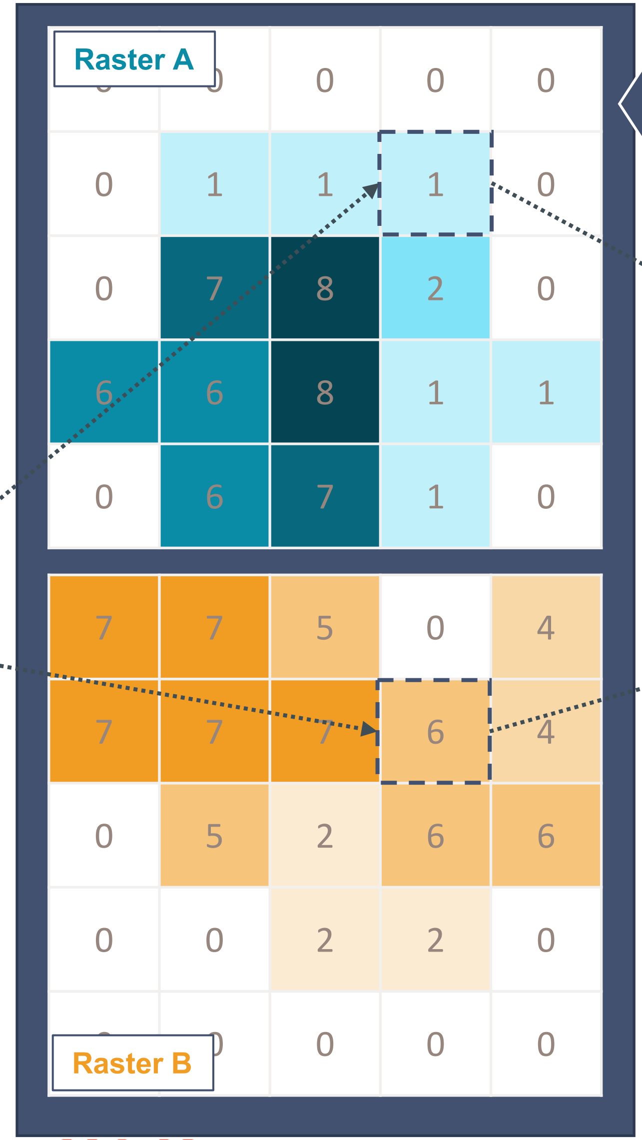
Feature class specs (reference_fc inherited from Factor class)

DominantFactor.value_field= field in feature class for grouping features during analysis (shown by symbol color)

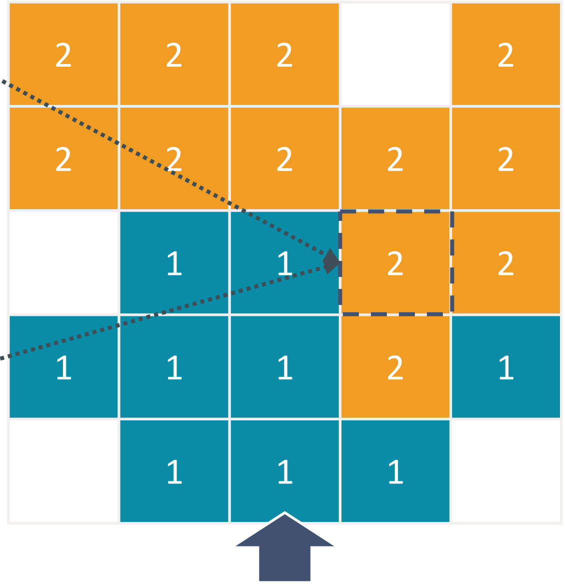
DominantFactor.weight_field= field in feature class to measure during analysis (shown by symbol size)



Floating zone definition (inherited from Factor class)



Temporary rasters measure intensity of values by each group. Here, raster A represents the intensity of the blue dots and raster B represents the intensity of the orange dots (groupings based on the value_field). Each rasters' values are weighted by the values in the weight_field for each feature



The resulting raster returns the integer of the index for the raster that has the highest value. In the outlined cell, the value in raster B (6) is higher than the value in raster A (1). The index for raster B is 2, since it was the second raster analyzed. Thus the resulting value is 2.

LINEAR SUM CLASS

LINEAR SUM CLASS (SUBCLASS OF FACTOR)

Primary purpose: create a Surface object by creating three temporary rasters for calculating a simple sum of values associated with polyline features in the floating zone area

- Major attributes:
  - weight_field: The polyline values to summarize.
  - line_id_field: A field that uniquely identifies each polyline feature. This is required for counting features for the summarization calculation.
- Major methods:
  - rasterize: Creates three rasters of linear statistics: variety of line id's (count of features), cumulative length of line features, weighted length of line features (weighted by weight field); these are then used in an expression to obtain a simple sum of weight_field values (weighted length/(cumulative length/count)).
- Also inherits attributes and methods from the Factor and Surface classes
- The "SUM/LENGTH" analysis method in the factor class produces a weighted sum (value field * feature length) for linear features, reflecting the behavior of SpatialAnalyst's Linear Statistics tool. The LinearSum class accounts for line length and number of line features to provide a simple sum of linear values in a neighborhood.

LINEAR SUM CLASS (SUBCLASS OF FACTOR)

Feature class specs (reference_fc inherited from Factor class)

LinearSum.weight_field= field in feature class for to be summed (shown by bandwidth)

LinearSum.line_id_field= field in feature class to uniquely identify each line feature(shown by line color)

Floating zone definition (inherited from Factor class)

The LinearSum class allows the values on the blue and red lines to be summed together.

The "SUM/LENGTH" method of the Factor class weights line values by line length, resulting in summary values that may be difficult to interpret. The LinearSum class automates a series of *LinearStatistics* geoprocessing runs to calculate a simple sum of line values.

OVERLAY CLASS

OVERLAY CLASS (SUBCLASS OF SURFACE)

Primary purpose: create a new Surface object by overlaying two or more existing Surface objects

- Major attributes:
  - surfaces: What Surface objects (usually Factor objects) will be used in the overlay?
  - surface_weights: What weight should be assigned to each surface object listed in surfaces?
    - Python dictionary ({surface_object.name: weight})
  - evaluation_scale: What range of resulting values will be produced by the overlay analysis?
    - Python list ([from_value, to_value, by_value])
- Major methods:
  - addSurface/dropSurface: Manage which surfaces will be included in the overlay analysis
  - updateSurfaceWeights: Manage how surfaces will be weighted in the overlay analysis
  - overlaySurfaces: Run the weighted overlay analysis
- Also inherits attributes and methods from the Surface class

OVERLAY CLASS (SUBCLASS OF SURFACE)

Raster A (34)

3	3	4	4	5
2	3	3	4	5
1	2	3	3	5
1	1	3	3	4
1	1	3	3	3

Raster B (33)

3	4	4	6	6
2	3	4	6	6
2	2	3	4	4
2	2	3	3	4
2	2	3	3	4

Raster C (33)

2	4	4	4	5
1	2	4	5	5
1	1	2	3	4
1	1	2	3	3
1	1	1	2	3

Overlay.surfaces = Input rasters that will be overlaid and analyzed. For this illustration, three surfaces will be analyzed.
Overlay.surface_weights = a dictionary containing the surface names and weights for use in the weighted overlay analysis. For this illustration, all surfaces are effectively weighted equally (see parenthetical values, which must sum to 100).

OVERLAY CLASS (SUBCLASS OF SURFACE)

Raster A (34)

3	3	4	4	5
2	3	3	4	5
1	2	3	3	5
1	1	3	3	4
1	1	3	3	3

Raster B (33)

3	4	4	6	6
2	3	4	6	6
2	2	3	4	4
2	2	3	3	4
2	2	3	3	4

Raster C (33)

2	4	4	4	5
1	2	4	5	5
1	1	2	3	4
1	1	2	3	3
1	1	1	2	3

3,3,2	3,4,4	4,4,4	4,6,4	5,6,5
2,2,1	3,3,2	3,4,4	4,6,5	5,6,5
1,2,1	2,2,1	3,3,2	3,4,3	5,4,4
1,2,1	1,2,1	3,3,2	3,3,3	4,4,3
1,2,1	1,2,1	3,3,1	3,3,2	3,4,3

The three surfaces are overlaid and their values combined. Corresponding cells in the input rasters represent the same location using different measures. Thus the outlined cell is a single location, with values of 4, 6, and 5 in rasters A, B, and C respectively.

OVERLAY CLASS (SUBCLASS OF SURFACE)

Raster A (34)

3	3	4	4	5
2	3	3	4	5
1	2	3	3	5
1	1	3	3	4
1	1	3	3	3

Raster B (33)

3	4	4	6	6
2	3	4	6	6
2	2	3	4	4
2	2	3	3	4
2	2	3	3	4

Raster C (33)

2	4	4	4	5
1	2	4	5	5
1	1	2	3	4
1	1	2	3	3
1	1	1	2	3

3	4	4	5	5
2	3	4	5	5
1	2	3	3	4
1	1	3	3	4
1	1	3	3	3

*If the rasters were weighted differently, say 80-10-10, the resulting raster values would be calculated differently. For the outlined cell, for example, the value would be 4. ((4 * 80) + (6 * 10) + (5 * 10)/100 = (320 + 60 + 50)/100 = 430/100 = 4.3)*

Since all input rasters are weighted equally, the resulting raster is effectively the mean of the overlaid input rasters, rounded to the nearest integer. Thus, the outlined cell has a final output value of 5 (the mean of the input raster values of 4, 6, and 5).

COMBINATION CLASS

COMBINATION CLASS (SUBCLASS OF SURFACE)

Primary purpose: create a new Surface object by combining two or more existing Surface objects

- Major attributes:
  - base_surface: The Surface object that will be modified based on the combination
  - adjustment_surfaces: The Surface object(s) that will be combined with the base_surface to return new values
    - Python dictionary ({surface_object.name: *parameters*})
  - adj_above_vaule/adj_below_value: The values in the base_surface raster above or below which adjustments from combinations will apply. Values outside of these bounds will retain their original value in the base_surface raster.
- Major methods:
  - combineSurfaces: execute the combination, returning resulting values based on the type of combination desired (see next slides on subclasses) according the specified parameters.
- Also inherits attributes and methods from the Surface class

COMBINATION CLASS (SUBCLASS OF SURFACE)

- Subclasses of Combination:
  - ConditionalCombination
  - CalculationCombination
  - LookupCombination

CONDITIONAL COMBINATION (SUBCLASS OF COMBINATION)

Primary purpose: create a new Surface object by combining two or more existing Surface objects, based on if-then style conditions

- Major methods:
  - addAdjustmentSurface: Update the adjustment_surfaces attribute (from Combination class), specifying the following parameters
    - adj_surface_obj: the adjustment surface object to be added
    - comparison: the comparison operation ("==3", ">3", "<=3", etc.) to use when applying the conditional logic in combining Surface objects
    - val_if_true: the value to return if the comparison returns a value of "TRUE"
    - val_if_false: the value to return if the comparison returns a value of "FALSE"
      - Use "base" to revert to the value in the base_surface raster when false
- Also inherits attributes and methods from the Combination class

CONDITIONAL COMBINATION (SUBCLASS OF COMBINATION)

2	4	4	4	5
1	2	4	5	5
1	1	2	3	4
1	1	2	3	3
1	1	1	2	3

base_surface = The input raster that will be adjusted by any adjustment_surfaces

0	2	2	4	4
0	2	4	4	4
0	0	2	2	2
0	0	0	2	0
0	0	0	0	0

adjustment_surface = The input raster that will be used to modify the base_surface

>= 2, 9

2	9	9	9	9
1	9	9	9	9
1	1	9	9	9
1	1	2	9	3
1	1	1	2	3

comparison = The condition to check for in the adjustment_surfaces

val_if_true = The new value to be assigned if the condition is true

CONDITIONAL COMBINATION (SUBCLASS OF COMBINATION)

2	4	4	4	5
1	2	4	5	5
1	1	2	3	4
1	1	2	3	3
1	1	1	2	3

0	2	2	4	4
0	2	4	4	4
0	0	2	2	2
0	0	0	2	0
0	0	0	0	0

>= 2, 9

2	9	9	9	9
1	9	9	9	9
1	1	9	9	9
1	1	2	9	3
1	1	1	2	3

Applying the condition…

- For the outlined cell,
  - the base_surface value is 4
  - The adjustment_surface value is 4
  - The condition is then applied using the comparison and the val_if_true
    - The conditions is TRUE (adjustment surface value of 4 is >= 2), so the resulting value is 9
- For all cells with adjustment surface values <2, the base surface value is retained, since there is no val_if_false attribute assigned

CONDITIONAL COMBINATION (SUBCLASS OF COMBINATION)

2	4	4	4	5
1	2	4	5	5
1	1	2	3	4
1	1	2	3	3
1	1	1	2	3

0	2	2	4	4
0	2	4	4	4
0	0	2	2	2
0	0	0	2	0
0	0	0	0	0

>= 2, 9

2	~~9~~4	~~9~~4	~~9~~4	~~9~~5
1	9	~~9~~4	~~9~~5	~~9~~5
1	1	9	3	~~9~~4
1	1	2	3	3
1	1	1	2	3

Applying limits…

- Limits (adj_above_val/adj_below_val) affect which cells will be subject to the conditional logic
  - If adj_below_val = 3, only cells having a base surface of 2 or lower will be subject to the condition (dark borders)
  - All other base surface values are passed through without the application of the condition

CALCULATION COMBINATION (SUBCLASS OF COMBINATION)

Primary purpose: create a new Surface object by combining two or more existing Surface objects, based on a mathematical expression

- Major attributes:
  - adj_lbound/adj_ubound: The lower/upper bound to apply to the calculation result
- Major methods:
  - addAdjustmentSurface: Update the adjustment_surfaces attribute (from Combination class), specifying the following parameters
    - adj_surface_obj: the adjustment surface object to be added
    - operator: the mathematical operator (“+”, “-”, “*”, “/” etc.) to use when applying the mathematical logic in combining Surface objects
    - surface_expr: any additional mathematical logic that should follow after the operator
- Also inherits attributes and methods from the Combination class

CALCULATION COMBINATION (SUBCLASS OF COMBINATION)

2	4	4	4	5
1	2	4	5	5
1	1	2	3	4
1	1	2	3	3
1	1	1	2	3

+

0	2	2	4	4
0	2	4	4	4
0	0	2	2	2
0	0	0	2	0
0	0	0	0	0

“/2.0”

2	5	5	6	7
1	3	6	7	7
1	1	3	4	5
1	1	2	3	3
1	1	1	2	3

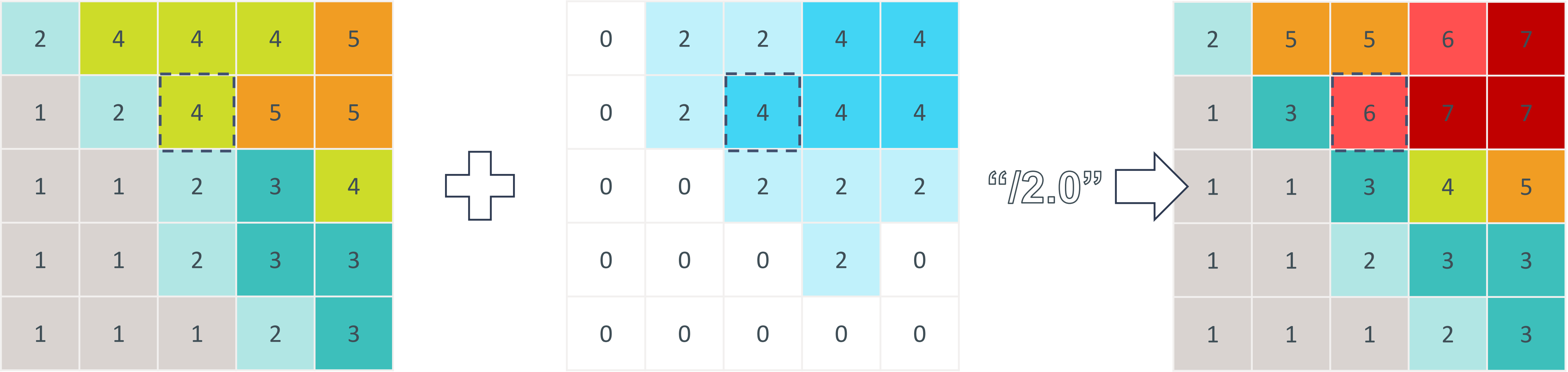
base_surface = The input raster that will be adjusted by any adjustment_surfaces

adjustment_surface = The input raster that will be used to modify the base_surface

operator = The mathematical operation to be applied to this adjustment_surface

surface_expr= Any additional mathematical logic to be applied to this adjustment_surface

CALCULATION COMBINATION (SUBCLASS OF COMBINATION)



Applying the calculation…

- For the outlined cell,
  - the base_surface value is 4
  - The adjustment_surface value is 4
  - The calculation is then applied using the operator and the surface_expr
    - Expression = “{base surface value} {operator} ({adjustment surface value} {surface_expr})”
    - Expression = 4 + (4/2) = 4 + 2 = 6

CALCULATION COMBINATION (SUBCLASS OF COMBINATION)

2	4	4	4	5
1	2	4	5	5
1	1	2	3	4
1	1	2	3	3
1	1	1	2	3

+

0	2	2	4	4
0	2	4	4	4
0	0	2	2	2
0	0	0	2	0
0	0	0	0	0

"/2.0"

2	5	5	6	~~7~~6
1	~~3~~2	6	~~7~~6	~~7~~6
1	1	~~3~~2	4	5
1	1	2	3	3
1	1	1	2	3

Applying bounds and limits…

- Limits (adj_above_val/adj_below_val) affect which cells will be subject to the calculation
  - If adj_above_val = 2, only cells having a base surface of 3 or higher will be subject to the calculation (dark borders)
- Bounds (ubound/lbound) control the output of the calculation
  - If ubound = 6, any resulting value greater than 6 will be capped at 6 (red areas)

LOOKUP COMBINATION (SUBCLASS OF COMBINATION)

Primary purpose: create a new Surface object by combining two or more existing Surface objects, based on a table of combined values

- Major attributes:
  - lookup_table: The table defining how combinations of values will be reclassified
  - base_surface: The Surface object that serves as the "base" for the reclass. Any combination of values not addressed in the lookup table will be assigned their "base" value.
  - adjustment_surfaces: List of additional Surface objects that will be combined with the base surface. Resulting combinations of values will be reclassed according to the data in the lookup_table.
- Major methods:
  - addAdjustmentSurface: Update the adjustment_surfaces attribute (from Combination class), specifying the following parameters
    - lookup_column: the column in the lookup_table that corresponds to this surface, ensuring that value combinations are looked up properly
- Also inherits attributes and methods from the Combination class

LOOKUP COMBINATION (SUBCLASS OF COMBINATION)

2	4	4	4	5
1	2	4	5	5
1	1	2	3	4
1	1	2	3	3
1	1	1	2	3

base_surface

0	2	2	4	4
0	2	4	4	4
0	0	2	2	2
0	0	0	2	0
0	0	0	0	0

adjustment_surface

2	9	9	4	6
1	2	4	6	6
1	1	2	3	9
1	1	2	3	2
1	1	1	2	2

Base value	Adj value	Reclass value
3	0	2
4	2	9
5	2	9
5	4	6

Lookup table – for combinations of values in the base and adjustment tables, assign the new raster a new value. For unspecified combinations, retain the base value

Glossary of Key Terms

The following definitions explain several key terms related to RED Lanes planning and implementation described in this report.

Access Class: classification of streets and highways reflecting the appropriate spacing of driveways, signals, median openings, etc., for the intended function of a corridor to provide a basic sense of how smoothly traffic will flow through the corridor.

Activity Density: the number of jobs and people per acre. Activity unit density is an indicator of a transit-supportive context.

Bus Rapid Transit (BRT): defined by the Federal Transit Administration (FTA) as "a high-quality bus-based transit system that delivers fast and efficient service that may include dedicated lanes, busways, traffic signal priority, off-board fare collection, elevated platforms and enhanced stations."

Business Access and Transit (BAT): alternative term used to describe similar transit priority strategies utilized in RED Lanes.

Candidate Corridor Scoping Sheets: succinct summaries of the corridors considered most suitable for RED Lanes treatments as a result of the prioritization process with suggestions for scoping the next phase of studies needed for implementation

Complete Streets: a context-sensitive facility and roadway design approach that accounts for all users in the ROW, enhancing safety, comfort, and efficiency for all users across modes.

Core Technical Team (CTT): a technical advisory group of local and regional jurisdictional representatives who provided guidance on transit planning and operational needs and values during the development of the RED Lanes prioritization process and toolkit.

Dimensions: for the purposes of this report, the term "dimension" describes one of the four principal groupings used to categorize individual Metrics for the purposes of assigning judgment values in a weighting process: demand, transit operations, highway operations, and context/design.

Fixed-guideway Bus Rapid Transit: BRT projects that include a dedicated lane for transit vehicles during peak traffic periods for at least 50% of the BRT corridor length.

Functional Class: classification of streets and highways reflecting their roles in the transportation system, for the intended function of a corridor and to provide a basic sense of how traffic will flow through the corridor. Functional classes are typically designated by numerical categories where 1 is the highest order facility type focused on inter-regional travel such as interstate highways and ascending values reflect an increasingly local orientation.

Level of Service (LOS): a term used to qualitatively describe the operating conditions of transportation systems (including auto, transit, bicycle, and pedestrian modes) based on factors such as speed, travel time, maneuverability, delay, and safety.

Metric: for the purposes of this report, the term "metric" describes the basic unit of quantitative data to generate suitability scores. Metrics are grouped into scores and weighted both within and across dimensions.

Person Throughput: the total number of people moving through a corridor, regardless of mode. For example, a carpool of three co-workers commuting to work would contribute three person trips to the person throughput value for the segments they traverse, while 25 people on a bus would contribute 25 person trips to the segments along the bus route between stops.

Queue Jumps or Queue Bypasses: short transit lanes intended to allow transit vehicles to bypass congestion and move to the front of a queue. They may be appropriate at bottleneck locations, usually at intersections.

Raster: a spatial data structure consisting of a matrix of evenly sized grid cells. Each cell contains a value representing information, such as the density of activity in the block group where the cell is located or the total transit ridership along routes within 200 feet of the cell's center.

Segment Smoothing: The process by which suitability scores recorded in raster cells are assigned and generalized to street segments overlapping the cells. Smoothing generates a typical scores for street segments such that the resulting segments are of a minimum length and snap to intersection locations.

Transit Mode Share: describes the percentage of total trips made using a transit mode. Mode share for an area reflects the cumulative mode choices of individual travelers making trips to/from that area; these individual choices may be affected by the availability of modal options (transit service, household vehicle availability, etc.), socio-economic and demographic characteristics (family size, income, etc.), and built environment characteristics (land use diversity, network connectivity, etc.).

Transit Oriented Development: growth strategy which aims to concentrate new development in strategic locations to optimize existing infrastructure and enhance transit utilization.

Transit Priority Lanes: a general term for a portion of the street designated by signs and markings for the preferential or exclusive use of transit vehicles, sometimes permitting limited use by other vehicles.

Transit Signal Priority (TSP): a method for increasing transit vehicle speed and improving reliability through the adjustment of signal timing at intersections. TSP typically extends a green phase or truncates a red phase if a transit vehicle is attempting to enter an intersection, thereby decreasing the delay likely to be experienced at a signalized intersection.

Volume to Capacity (V/C) Ratio: measures the level of congestion on a roadway by dividing the volume of traffic by the capacity of the roadway.