
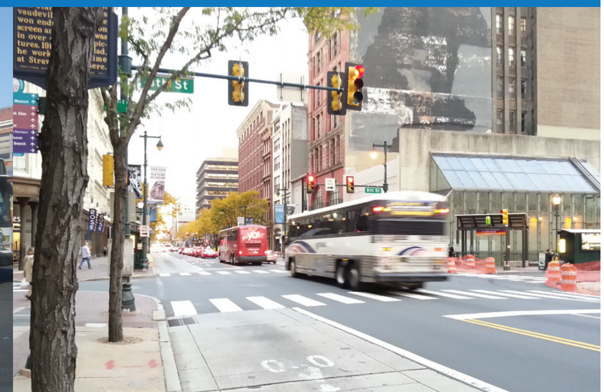

Transit Signal Priority Favorability Score:
Development and Application in Philadelphia and Mercer County

DELAWARE VALLEY
dvrpc
REGIONAL
PLANNING COMMISSION

April 2014

The Delaware Valley Regional Planning Commission is dedicated to uniting the region's elected officials, planning professionals, and the public with a common vision of making a great region even greater. Shaping the way we live, work, and play, DVRPC builds consensus on improving transportation, promoting smart growth, protecting the environment, and enhancing the economy. We serve a diverse region of nine counties: Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer in New Jersey. DVRPC is the federally designated Metropolitan Planning Organization for the Greater Philadelphia Region — leading the way to a better future.

The symbol in our logo is adapted from the official DVRPC seal and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

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Executive Summary

Transit agencies are increasingly looking to prioritize investments that can be implemented at relatively low cost, such as Transit Signal Priority (TSP). This report details a method of scoring corridors on their likelihood for successful and cost-effective TSP and related signal investments. This project was funded and conducted as two separated projects in the DVRPC FY2013 Unified Planning Work Program: Prioritizing Corridor Signal Upgrades for Transit First (City of Philadelphia), funded from the Pennsylvania Transit Support Program, and Feasibility Assessment for Transit Signal Priority, funded from the New Jersey Transit Support Program. This report summarizes the findings of each of these projects.

The study team has built upon prior data gathering, analysis, and mapping work to develop a TSP prioritization framework. The screening tool that was developed identifies the corridors where TSP is likely to be the most effective and have the greatest operational benefits for transit and all road users, drawing on measures that are a) available at the corridor or county level, b) simple and legible, and c) transparently related to anticipated TSP success, either positively or negatively. To inform project decision making in Philadelphia and Mercer counties, DVRPC staff developed a set of high-level prioritization criteria to evaluate and compare prospective TSP corridors. These criteria vary slightly between Philadelphia and Mercer counties, and are based on a review of industry best practices and available data sources. This report summarizes scores by transit route and by road segment. The tables below summarize the top-10 scores by road segment and transit route for both Philadelphia and Mercer County.

ES Table 1: Top-10 TSP Favorability Scores for Road Segments in Philadelphia

Rank	Bus Routes	TSP Score	Street Segment
1	16, 22, 80, XH	44.625	Cheltenham Ave. between Broad St. and Andrews St.
2	6, 16, 22, 80, H, XH	43.875	Cheltenham Ave. between Andrews St. and Vernon Rd.
3	47, 70, K	43	5th Street between Chew Ave. and Ridley St.
4	16, 22, 80, 55	43	Broad Street between Cheltenham Ave. and Oak Lane Ave.
5	28, 66	42.625	Frankford Ave between Lansing St. and Strahle St.
6	8, 16, 18, 22, 26, 55, 80, J	42.5	Broad Street between Louden St. and Chew St.
7	66, 70	42.5	Frankford Ave. between Strahle St. and Arendell Ave.
8	9, 10, 11, 13, 30, 31, 34, 36, 44, 62, 78, 124, 125, LUCY	42.5	Market Street between Frankford Ave. and 23rd Street
9	18, 24	42.25	Rising Sun Ave. between Colgate St. and Princeton Ave.
10	19, 66, 84	42	Frankford Ave. between Arendell Ave. and Morrell Ave.

Source: DVRPC 2013

ES Table 2: Top-10 TSP Favorability Scores for SEPTA Surface Routes in Philadelphia

Rank	Route	TSP Score	Terminus	Terminus
1	66	39.80	Frankford Transportation Center	Frankford-Knights (NE Philly)
2	16	36.81	Cheltenham-Ogontz	City Hall
3	56	36.43	23rd-Venango/ Bakers Centre	Torresdale-Cottman
4	18	35.03	Fox Chase	Cedarbrook Plaza
5	22	34.98	Warminster and Willow Grove	Olney Transportation Center
6	80	34.98	Express Horsham	Olney Transportation Center
7	21	34.86	Penn's Landing	69th Street Transportation Center
8	23	34.61	Broad-Oregon	Chestnut Hill
9	44	34.43	5th-Market	Ardmore
10	9	34.23	4th-Walnut	Andorra

Source: DVRPC 2013

ES Table 3: Top-10 TSP Favorability Scores for Segments in Mercer County with Existing Bus Service

Rank	Bus Routes	TSP Score	Street Segment	City
1	409, 600, 602, 603, 604, 607, 611, 613	47.25	Broad Street between State Hwy. 33 and Old Rose St.	Trenton
2	409, 418, 600, 602, 603, 604, 607, 611, 613	45.25	Martin Luther King, Jr. Boulevard between Broad Street and Sanford St.	Trenton
3	409, 603, 607, 613	44.00	Broad Street between Irving Pl. and Lalor St.	Trenton
4	409, 418, 604, 608, 611	43.75	State Street between Clinton Ave. and Olden Ave.	Trenton
5	409, 418, 600, 601, 606, 608, 609, 611, 619	43.50	Clinton Avenue between Mott St. and Model Ave.	Trenton
6	409, 418, 600, 601, 606, 608, 609, 611, 619	42.25	State Street between Montgomery St. and Clinton Ave.	Trenton
7	418, 601, 606, 608, 609, 619,	42.25	State Street between US 1 (Trenton Fwy.) and Green Pl.	Trenton
8	409, 603, 607, 613	42.00	Broad Street between Maddock Ave. and Lily St.	Hamilton
9	600, 602, 604, 611	42.00	Perry Street between Clinton Ave. and Martin Luther King, Jr. Blvd.	Trenton
10	409, 600, 602, 611	41.25	Front Street between Stockton St. and US 1 (Trenton Fwy.)	Trenton

Source: DVRPC 2013

ES Table 4: Top-10 TSP Favorability Scores for NJ Transit Bus Routes in Mercer County

Rank	Bus Route	TSP Score	Terminus	Terminus
1	409	38.30	Trenton Transit Center	Philadelphia
2	608	35.48	Hamilton Township	West Trenton
3	611	34.72	Trenton Transit Center	Trenton River View Plaza
4	609	34.55	Ewing Township	Lawrence Township
5	619	33.75	Ewing Township	Lawrence Township
6	604	33.02	East Trenton	Trenton Transit Center
7	655	31.98	Princeton	Plainsboro Township
8	607	31.40	Ewing Township	Hamilton Township
9	601	31.11	Ewing Township (TCNJ)	Hamilton Township
10	603	30.79	Lawrence Township	Hamilton Township

Source: DVRPC 2013

Chapter 1: Introduction

Transit agencies are increasingly looking to prioritize investments that can be implemented at relatively low cost, such as Transit Signal Priority (TSP). This study develops a method of scoring corridors on their likelihood for successful and cost-effective TSP and related signal investments. The study team has built upon prior data gathering, analysis, and mapping work to develop a TSP prioritization framework. The screening tool that was developed identifies the corridors where TSP is likely to be the most effective and have the greatest operational benefits for transit and all road users, drawing on measures that are a) available at the corridor or county level, b) simple and legible, and c) transparently related to anticipated TSP success, either positively or negatively.

This project was funded and conducted as two separated projects in the DVRPC FY2013 Unified Planning Work Program: Prioritizing Corridor Signal Upgrades for Transit First (City of Philadelphia), funded from the Pennsylvania Transit Support Program, and Feasibility Assessment for Transit Signal Priority, funded from the New Jersey Transit Support Program. This report summarizes the findings of each of these projects.

Project Background and Approach

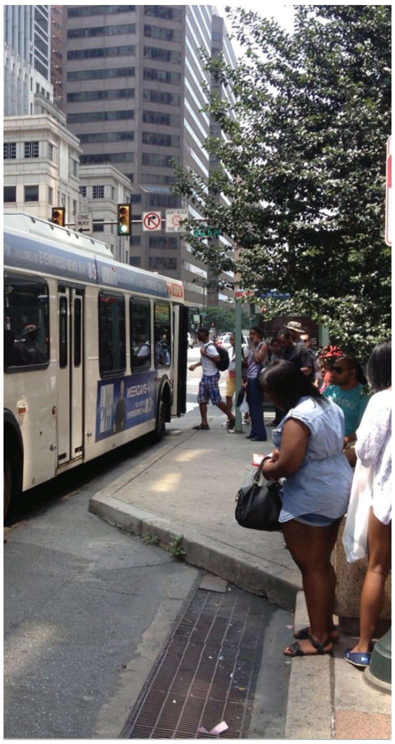
In order to maximize the effectiveness of our existing public transit network during a time when expansion is financially challenging, low-cost tools such as TSP are increasingly under consideration to improve transit throughout the region. The Transit First Committee, a cooperative venture between the City of Philadelphia, SEPTA, and DVRPC, has made collaborative efforts to enhance transit efficiencies by improving service speeds through low- or no-cost strategies. This working group has identified TSP as an important element in the toolkit of strategies that seek to improve the effectiveness and attractiveness of surface transit in Philadelphia.

In Mercer County, TSP has been suggested in prior planning efforts, such as the NJ TRANSIT Central Jersey BRT plan and the *Mercer County Future Bus Plan*, as a way to improve the effectiveness and attractiveness of bus transit. As a result of this prior analysis, a county prioritization framework has been developed so that as funding becomes available, it can be directed to the most effective projects.

To inform project decision making in Philadelphia and Mercer counties, DVRPC staff developed a set of high-level prioritization criteria to evaluate and compare prospective TSP corridors. These criteria vary slightly between Philadelphia and Mercer counties, and are based on a review of industry best practices and available data sources. In Philadelphia, the criteria built upon prior work by DVRPC's Office of Transportation Operations Management, which has gathered and mapped data regarding the location and characteristics of operations and Intelligent Transportation System (ITS) equipment locations, as well as feedback from the advisory commitee. In Mercer County, the criteria were revised for the suburban operating context and from feedback from Mercer County partners.

Transit Signal Priority Description, Objectives, and Cost Savings

Public transit vehicles in the Delaware Valley Region (buses, trackless trolleys, and trolleys) commonly operate on roadways without dedicated lanes. During peak periods, when roadways are typically congested, signal delay can significantly impair transit running times, especially where there is short intersection spacing, making service less reliable for passengers. One tool for enhancing service is TSP, or providing public transportation vehicles with preferential treatment at traffic signals. The primary objectives of TSP are to decrease transit travel times, improve schedule adherence, mitigate emissions, relieve congestion, and potentially reduce headways where time savings are sufficient to make that possible.



TSP is a modification of the phase split times of a traffic signal. In some cases, the approaching transit vehicle receives a green phase when it arrives at the signal (signal preemption). Generally, however, the green phase is extended or the red phase truncated (signal priority) to provide more time for the transit vehicle to pass through the intersection. TSP can be implemented at a single intersection or at a number of intersections along a transit corridor. Signal times given to the transit vehicle upon TSP actuation are generally recovered on the following signal cycle or cycles, still allowing for signal loop coordination. TSP is particularly effective when combined with complementary time savings strategies, such as stop consolidation or the relocation of near-side bus stops to the far side of an intersection.

TSP is often found to work best with far-side transit stops, as this allows the transit vehicle to clear the intersection before stopping to load/unload passengers. As a result, the time that it takes the transit vehicle to clear the intersection after being detected by the controller is more predictable. Alternatively, the major benefit of TSP for near-side stops, especially under moderately congested conditions, is the ability to clear the general traffic queue between a transit vehicle and the near-side stop. This allows the transit vehicle to only stop once, if at all, instead of twice—once behind the vehicle queue to reach the stop, and a second time while waiting to load and unload passengers.

One indicator to assess service effectiveness for transit vehicles is operating speed (or end-to-end running times). Faster service makes public transportation more competitive with the automobile which, in turn, can attract additional riders. Furthermore, when transit vehicles are operating at higher speeds, it makes service less expensive per mile because the same frequencies can be realized with fewer vehicles. Cost savings owing to speed improvement become particularly significant when there are travel time savings of more than one headway, achieving the same service frequency with one less vehicle: the "save a bus" principal.[1] This cost savings can be used to offset higher levels of service, capital costs, or maintenance costs, which can help to further attract new ridership.

Types of TSP Technology

There are two common types of TSP implementation in practice: active and conditional. Active TSP is where a request for signal priority is sent by the on-board vehicle detector to a signal controller, which will grant priority if possible. The signal at an intersection changes as each bus is detected by the signal controller. Conditional TSP allows for transit priorities to be predefined by conditions or scenarios, and has capabilities to allow vehicles to interact with one another. For example, a vehicle with higher priority, such as an express bus, could get green time over a local bus. TSP can be implemented in various ways. At a minimum, active and conditional TSP require technology to detect an approaching transit vehicle at an intersection and the ability for signal priority requests to be sent by the transit vehicle to the signal controller, which will grant priority if possible. The DVRPC study team identified four types of TSP

1 Delaware Valley Regional Planning Commission. Speeding Up SEPTA: Finding Ways to Move Passengers Faster. August 2008 (DVRPC publication no. 08066).

equipment that can be installed theoretically or are used in practice. These are summarized below.

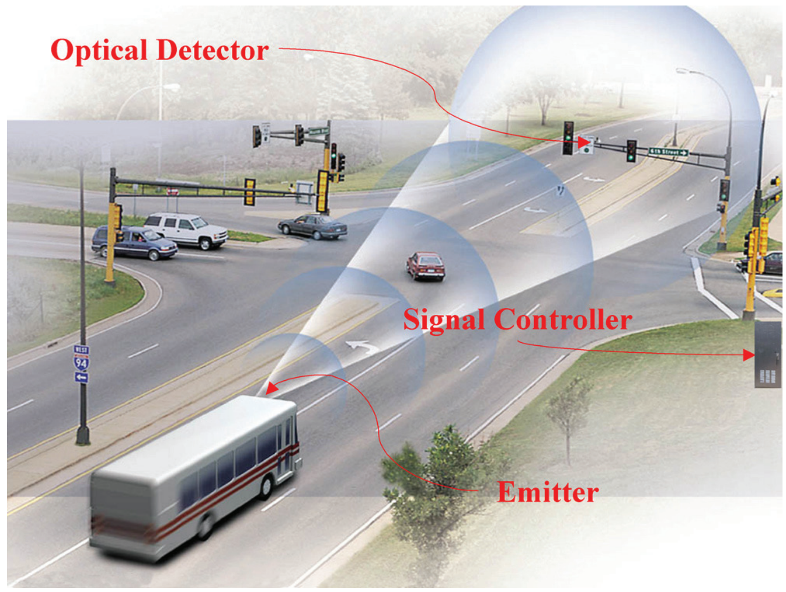
- Many transit fleets now include **Global Positioning System (GPS)** units installed on transit vehicles to transmit the vehicle location, speed, direction, and time of day. This technology can be adapted to interface with traffic signal controllers for TSP.

- **Loop-Detection equipment** works using an inductive loop embedded in the roadway pavement and a transponder mounted on the underside of the transit vehicle to distinguish transit vehicles from other traffic.

- **Optical/infrared detection** transmits from an on-board transit emitter to a detector mounted at the intersection, which connects to the traffic signal controller to modify signal timing. This system requires line of sight between the transit vehicle emitter and signal receiver; additional maintenance to maintain that line of sight via trees and branch clearance may be required.

- Another detection system is based on a network of **WiFi wireless cards** transmitted by radio waves between the transit vehicle and the controller at the intersection.

Figure 1: Infrared/Optical Visual



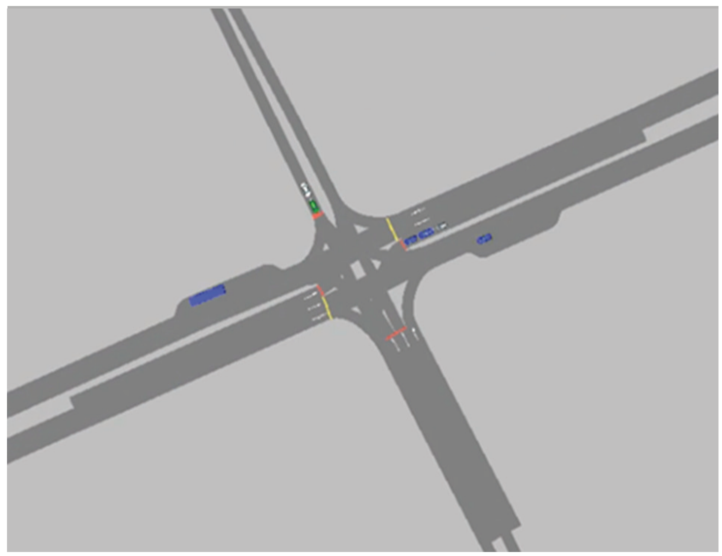
Source: Global Traffic Technologies

Nationally, it is increasingly common for traffic signals to have some type of vehicle detection device (most likely optical or infrared) for emergency vehicle preemption. This can provide a less costly platform for TSP implementation, but can also present vehicle conflicts between the emergency and transit vehicles if not handled carefully.

Regional Applications of TSP

TSP is not a new concept. It has been widely used in Europe, throughout North America, and regionally in Pennsylvania. In order to evaluate the cost effectiveness of prospective TSP investments, it is helpful to understand the levels of potential running time savings that can be achieved through TSP. DVRPC has explored the potential of TSP as an emerging best practice in prior planning projects with SEPTA. For purposes of order-of-magnitude time savings estimates, previous studies drew on the TSP experiences of Los Angeles and Portland in referencing a rule-of-thumb reduction of 6.8 percent in running time savings following TSP implementation.[1]

Figure 2: Microsimulation Snapshot of Route 104



Source: DVRPC 2010

Analytical models, and specifically microsimulation, provide a more sophisticated tool to explore the potential effectiveness of TSP along transit routes. Microsimulation focuses on a small area, such as an intersection or group of intersections. This is a powerful analytical tool because both vehicle and driver behavior are modeled in a realistic way at the vehicle level. Microsimulation models also offer the ability to evaluate multiple scenarios and combined alternatives. DVRPC conducted microsimulation analyses for Trolley Route 34 (surface stops only) in Philadelphia and Bus Route 104 in Chester and Delaware counties to evaluate various proposed TSP and stop- consolidation combinations. In the TSP base- case scenario modeled for Route 34 (no-stop consolidation), the model estimated an end-to-end running time savings of 7.5 percent eastbound and about five percent westbound. In the base-case TSP scenario for the Route 104 bus, the model estimated an average time savings of just 2.9 percent in both directions. These varying results relate to significant differences between the operating contexts of these two routes, urban versus suburban; lessons learned from these studies have informed the criteria choices for the present analysis.[2] [3]

There have also been previous TSP installations in Philadelphia that used optical/infrared equipment. This technology works using an optical emitter on vehicles that triggers an optical receiver on the traffic signal from a distance of 50 to 250 feet (or more), resulting—for prior Philadelphia installations—in a 10-second green phase extension for that signal. In 2004 and 2005, a demonstration installation of TSP using this approach was completed for Bus Route 52 at 50 intersections. In addition to TSP, a handful of near-side stop locations were also moved to the far side of intersections and two stops were removed from the route. A comparison of scheduled running times before and after the installation found an estimated 4.7 percent in time savings; however, due to other route changes and variations, it was difficult to assign a specific time savings for TSP alone.

In 2000, a similar TSP program, as well as a number of stop consolidations, was completed for Trolley Route 10 (surface stops only) at 26 intersections. A study comparing Route 10 travel times found that average surface travel times improved by 5.7 percent between 2000 and 2007 following TSP implementation. Unfortunately, it proved infeasible to keep this TSP operation in reliable service due to equipment obsolescence and replacement issues.

Most recently, in 2012, a new TSP pilot installation was completed for Route 10, where equipment was installed on

1 Delaware Valley Regional Planning Commission. Speeding Up SEPTA: Finding Ways to Move Passengers Faster. August 2008 (DVRPC publication no. 08066).
2 Delaware Valley Regional Planning Commission. Transit First Analysis of SEPTA Route 34. March 2010 (DVRPC publication no. 09040).
3 Delaware Valley Regional Planning Commission. Boosting the Bus: Better Transit Integration Along West Chester Pike. August 2011 (DVRPC publication no. 10033).

30 traffic signals and 18 vehicles. A before-and-after comparison found that there was approximately a 3.7 percent time savings using TSP under this pilot.

Overall, the findings of estimates, simulations, and demonstration projects indicate that TSP is more effective in some locations and for some routes than others, with wide variations across route operating contexts and corridor characteristics. The purpose of the present project was to develop a consistent scoring framework to help better predict the success of TSP investments across all routes and all corridors, in order to help prioritize future installations. Table 1 summarizes the travel time savings of the regional TSP case studies.

Table 1: Time Savings Summary for DVRPC Studies of TSP

SEPTA Route	Mode	Summary of End-to-End Travel Time Savings	Travel Time Savings (avg EB and WB)
10	City Trolley	TSP Implemented Pilot, Travel Time Run	5.7%*, 3.7%**
34	City Trolley	Modeled Travel Time	6.25%
52	City Bus	TSP Implemented Pilot	4.7%
104	Suburban Bus	Modeled Travel Time	2.9%

*Savings based on 2007 demonstration, **Savings based on 2012 pilot

Source: DVRPC 2013

Chapter 2: Philadelphia TSP Efforts, Favorability Criteria, and Results

Recent Philadelphia TSP Efforts

In 2011, the City of Philadelphia, in conjunction and coordination with partner agencies (SEPTA, PennDOT, and DVRPC), received two grant awards (TCSP and TIGER) to fund the installation of TSP on several corridors in the city. The City of Philadelphia, PennDOT, and SEPTA also contributed funds to this project. Philadelphia and SEPTA staff met, along with members of the Transit First Committee, to discuss the technological options that would be most compatible with SEPTA vehicles, traffic signals, and signal and traffic control systems in Philadelphia, and:

- Require low construction and maintenance costs.
- Demonstrate successful operation with the current transportation system.
- Have the ability to be used across multiple municipalities.
- Be compatible with SEPTA's existing automatic vehicle location (AVL) system and conditional priority for the future.
- Include functionality to distinguish between emergency response and transit vehicles and work for both.
- Have check-in and check-out capabilities.[1]

After considering these needs and more, the City of Philadelphia and SEPTA determined that optical/infrared detection would continue to be the preferred form of TSP to be implemented. This technology was primarily chosen because it is compatible with the existing AVL system and can be expanded to provide conditional priority in the future.

Six routes were chosen for the initial TSP implementation. The selected routes had high transit ridership, dense signals, commercial land use, geographic diversity, connections to the subway, and modal diversity.

The purpose of the DVRPC TSP Favorability Score project was to develop a robust citywide prioritization framework to assist with future TSP project selection.

Figure 3: Map of Recently Selected TSP Routes in Philadelphia

Source: City of Philadelphia 2013

1 Transit Signal Priority Grants & Technology TransAction Presentation, City of Philadelphia, 2013.

Philadelphia Analysis Criteria

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. The inputs are intended to account for as many relevant factors as possible that would affect optimal TSP deployment. This is an approach that is replicable elsewhere, but may be varied based on the local road network, public transportation system, density of the study area (urban, suburban, and rural), and locally available data sources. The TSP Favorability Score is a preliminary screening tool, and further review would be required prior to implementation to determine if a high scoring segment or corridor could truly be a successful location for TSP.

The raw data that was available for each criterion was reviewed, and following a check of the data's distribution, numerical values were grouped into bins to further organize the information and score each criteria. A consistent scoring framework made it possible to make an apples-to-apples comparison between criteria and aggregate them in an internally consistent way. The 10 criteria were divided into four categories: traffic, transit supply, transit demand, and planning priorities. A weighting scheme per category and per criteria was developed in consultation with the project's advisory committee to ensure that the criteria deemed most locally meaningful were given the greatest weight in the prioritization. Table 2 summarizes each of the criteria used in this analysis and their scoring. The farthest right column shows an example (Cheltenham Avenue) of the scores and weighted scores of the highest TSP Favorability segment in Philadelphia. Detailed explanations of each criteria follow.

Table 2: Criteria for Philadelphia TSP Screening Tool

Category	Criterion	Scoring Treatment	Weight	Score for Cheltenham Ave example segment (weighted score)
Traffic	Volume-to-capacity (V/C) ratio	0 = low, 5 = medium, 2.5 = high	0.5	5 (2.5)
Traffic	Cross-street V/C ratio (average)	5 = low, 2.5 = medium, 0 = high	0.25	2.5 (0.625)
Traffic	Traffic volumes (AADT)	5 quantiles; Higher values = higher score	0.5	5 (2.5)
Traffic	Cross-street traffic volumes (average)	5 quantiles; Lower values = higher score	0.25	4 (1)
Traffic	Signal density	5 quantiles; Higher values = higher score	1.5	4 (6)
Traffic	**Total for Traffic**		**3.0**	**20.5 (12.625)**
Transit Supply	Transit vehicle volumes	5 quantiles; Higher values = higher score	2.0	5 (10)
Transit Supply	Cross-street transit vehicle volumes (sum)	5 quantiles; Lower values = higher score	1.0	5 (5)
Transit Supply	Location of stops (% far-side stops)	More far side stops = higher score	0.5	1 (.5)
Transit Supply	Transit route length (sum)	5 quantiles; Higher values = higher score	0.5	4 (2)
Transit Supply	**Total for Transit Supply**		**4.0**	**15 (17.5)**
Transit Demand	Transit passenger volumes	5 quantiles; Higher values = higher score	1.0	5 (5)
Transit Demand	Cross-street transit passenger vols. (sum)	5 quantiles; Lower values = higher score	0.5	4 (2)
Transit Demand	Average trip length	5 quantiles; Higher values = higher score	0.5	5 (2.5)
Transit Demand	**Total for Transit Demand**		**2.0**	**14 (9.5)**
Planning Priorities	ICM	Yes = higher score	0.5	5 (2.5)
Planning Priorities	POInts	Higher POInts priority = higher score	0.5	5 (2.5)
Planning Priorities	**Total for Planning Priorities**		**1.0**	**10 (5)**
Total for All Criteria				**59.5 (weighted score 44.625)**

Source: DVRPC 2013

Traffic Criteria

The traffic criteria are intended to explore automobile traffic conditions in a prospective TSP corridor, and include the following measures: V/C ratio, cross-street V/C ratio, traffic volumes, cross-street traffic volumes, and signal density. As a whole, the traffic category was weighted three out of the 10 total points in the composite scoring framework.

► The **volume-to-capacity (V/C) ratio** is a standard measure of roadway congestion. Peak-hour volume-to-capacity (V/C) ratios were calculated for the 2012 DVRPC Congestion Management Process (CMP) by using several years of recent traffic counts and roadway capacities derived from the DVRPC Regional Travel Demand Model. The traffic counts were converted from Average Annual Daily Traffic (AADT) to peak-hour volumes. Precise capacities are not available for all roads, so the Travel Demand Model capacities were used since they were sufficient for the regionally scaled CMP analysis. The literature suggests that TSP is most effectively applied where there is significant, but not debilitating, traffic congestion. Therefore, V/C ratios were grouped into a range of bins of <0.75, 0.75 to 1.25, and >1.25, with the middle bin given the most favorable score.

► In addition to congestion levels along a corridor, it is also important to consider the congestion levels of cross-streets. The City of Philadelphia has a grid-based street network, and many roadways across the city are highly congested with both traffic and transit. If cross-street characteristics are not effectively considered, TSP along a given corridor could be counterproductive—inappropriately benefiting one corridor at the expense of others. To account for this issue, it was important for the tool to evaluate a given corridor's characteristics in comparison to its cross-streets. The average **V/C ratio for a given segment's crossing streets** was calculated using GIS. The same bins were used as V/C ratio, but for a higher average cross-street V/C, a lower (less favorable) score was assigned.

► **Traffic volumes** were used to reflect the general levels of auto activity along a corridor. A corridor with higher volumes represents higher numbers of motorists that can also benefit from the additional green signal time offered by TSP. For this project, the higher the traffic volumes according to DVRPC's database of regional AADTs, the higher the score input into the screening tool. In the process of aggregating and scoring the data, some assumptions were made when AADT data was incomplete for a roadway segment. For example, when there was no AADT available for a given segment, but the two segments on either side did have data and were of the same roadway classification, the volumes for these adjacent segments were averaged, with the resulting value being assigned to close the data gap. Where adjacent segments did not have sufficient data, remaining gaps were closed by assigning the average AADT for urban collectors in Philadelphia (7,600).

► Similar to the V/C ratio, cross-street traffic volumes that are greater than the segment being evaluated could result in counterproductive TSP implementation. As a result, lower **cross-street traffic volumes** were awarded higher scores in the tool.

► **Signal density** is a measure of the number of traffic signals per mile. In general, corridors with higher signal densities may lead to greater time savings from the application of TSP because transit vehicles are more likely to be impacted by signal delay. Therefore, a higher density of signals (as identified through the City of Philadelphia's traffic signals inventory) was awarded a higher score in the screening tool. Because this project used a network of same-length segments for analysis, signal count by segment was used as a proxy for density.

Transit Supply Criteria

The transit supply criteria are intended to reflect the level and characteristics of transit service in each corridor, and include the following measures: transit vehicle volumes, cross-street transit vehicle volumes, location of stops, and transit route length. The transit supply category was weighted four out of the total 10 points in the composite scoring framework.

► **Transit vehicle volumes** is a measure of all surface transit vehicles along a segment over a 24-hour period. Higher volumes mean a higher number of scheduled transit runs that could benefit from TSP. As a result, higher volumes were awarded a higher score in the screening tool. This data was derived from SEPTA General Transit Feed Specification (GTFS) schedule data, as processed through the DVRPC Regional Travel Demand Model.

- Similar to V/C ratio, **cross-street transit vehicle volumes** that are high could result in counterproductive TSP implementation by adding travel time to transit on the cross-streets. Total crossing transit vehicle volumes were calculated for each segment in GIS, with lower crossing vehicle volumes resulting in a higher score for this criterion.

- **Stop locations** are meaningful because far-side stops enhance TSP effectiveness (since intersection-clearance times are more predictable). A higher percentage of far-side stops resulted in a higher score.

- For this project, **transit route length** represents an average of route miles for each route operating on that segment. When a transit route has significant distance to travel, it has more of a chance to encounter bottlenecks. Conversely, with a longer transit route, there is a greater chance for meaningful time savings to be achievable using TSP because multiple intersections can add up to large time savings across an entire route. As a result, longer route lengths were awarded higher scores.

Transit Demand Criteria

The transit demand criteria are intended to reflect actual passenger demand in a given corridor, or the number of individual transit riders who stand to benefit from TSP. This set of criteria includes the following measures: transit passenger volumes, cross-street transit passenger volumes, and transit passenger average trip length. The transit demand criteria category was weighted two out of the 10 total points in the composite scoring framework.

Source: DVRPC 2013

- **Transit passenger volumes** reflect transit ridership (boardings plus alightings) along a segment. When transit passenger volumes are higher, more passengers demand service in that particular corridor, helping to justify investments like TSP to make service more efficient and reliable for active passengers and attractive to new passengers. Therefore, higher transit passenger volumes were awarded higher scores in the screening tool.

- Conversely, high **cross-street transit passenger volumes** were assigned lower scores; where cross-street passenger volumes are higher than passenger volumes along the corridor, TSP implementation can be counterproductive.

- SEPTA collects the **average passenger trip length** or the average distance ridden by a passenger for a given route, which was assigned to all segments traversed by a route. As transit passengers make longer journeys, TSP time savings become more perceptible to the individual rider. Where a road segment is shared by multiple SEPTA routes, trip length for each of those routes was averaged to assign a segment-level trip length, with higher average passenger trip lengths being awarded higher scores.

Planning Priorities Criteria

These criteria build upon prior work by DVRPC's Office of Transportation Operations Management, which has gathered and mapped data regarding the location and characteristics of operations and Intelligent Transportation System (ITS) equipment in Philadelphia. This category was weighted one out of the 10 total points in the composite scoring framework.

- **Integrated Corridor Management (ICM)** is a simple "yes or no" criterion determined by a TSP location falling into an ICM corridor, as identified in the DVRPC Transportation Operations Master Plan. ICM optimizes travel in a corridor by synchronizing traffic on expressways and arterials, as well as between highways and transit modes. The plan identifies potential corridors for ICM treatment. This is an established method that already has significance in the region; if a given segment is included in an ICM corridor, it was awarded a higher score.

- **Prioritization for Operational Investments (POInts)** is a separate, previously developed weighted system of criteria designed to identify priority locations for operational investment in Philadelphia. Note that the POints measure itself is derived from some of the same factors used here (such as signal density and route-level transit ridership), resulting in a small level of double counting for those factors. Higher POInts priorities were assigned higher scores in the screening tool.

Evaluation Process and Analysis

Once the scoring framework was established, the inputs were analyzed in GIS to create a composite TSP Favorability Score for each segment in the citywide network. The TSP Favorability Score is an overall approximation of the locations where TSP is likely to be most successful, considering a segment's overall transit and transportation context. This section details the process used to calculate the TSP Favorability Score.

The data for each criterion was mapped to a network of one-mile segments, which consisted of every signalized and bus carrying roadway. For route-level criteria (average passenger trip length and transit route length), route-level values were assigned to all segments traversed by that route, and then aggregated where multiple routes overlapped, as summarized in Table 2.

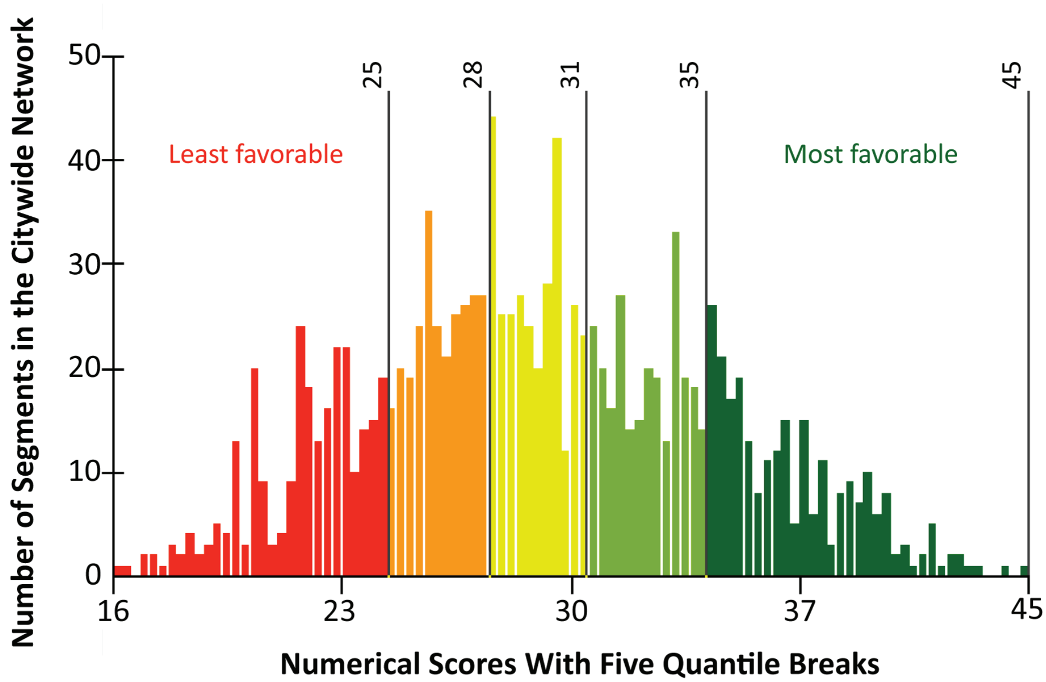
To calculate a segment's aggregated cross-street criteria (transit passenger volumes, V/C ratio, traffic volumes, and transit vehicle volumes), first the number of cross-streets (or crossing segments) for each segment was calculated using GIS. Next, the values for each crossing segment for each of the affected criteria were added or averaged, depending on the criteria, with the resulting value then appended to the segment being scored.

After the criteria were mapped and their numerical values were assigned to segments across the network, each segment was assigned scores for each criterion according to the scoring and weighting framework summarized in Table 2. These criteria-level scores were then added to create the composite TSP Favorability Score for each segment. The highest possible TSP Favorability Score that a segment could achieve was 50.

TSP Favorability Score Results

Conducting the analysis using a network of one-mile road segments allows corridors to be compared at various levels of granularity. For example, segment-level scores can be averaged for a longer segment or a given transit route, enabling apples-to-apples route-level comparisons. Figure 4 summarizes the distribution of citywide segment-level TSP Favorability Scores in a histogram. The range of scores is between 15.625 and 44.625, where the mean is 29.5. The histogram illustrates that the scores create a relatively normally distributed curve. Figure 5 illustrates the TSP Favorability Scores mapped across the City of Philadelphia. A few observations derived from a closer examination of the data illustrated in Figure 5 are as follows:

Figure 4: Histogram of Philadelphia TSP Favorability Scores



Source: DVRPC 2013

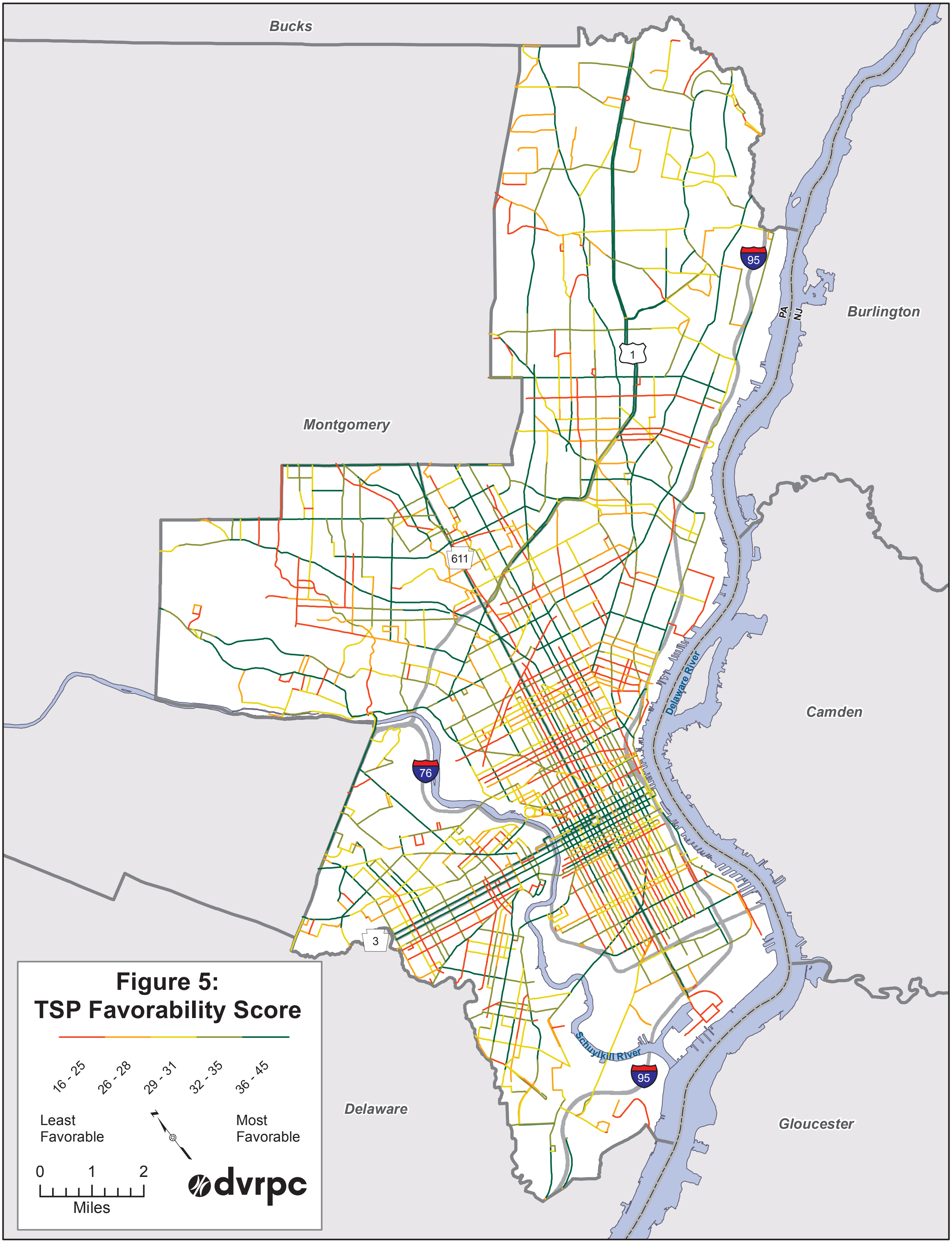
► The majority of the network's highest-scored segments are major arterials. This makes sense in the context of the analysis, as these are likely to be roadways with higher volumes and of generally higher priority for investment than their crossing streets. In particular, the arterials that are prevalent in the highest-rated segments are: Bustleton Avenue, Cheltenham Avenue, Frankford Avenue, and Market Street.

► Higher-ranked segments are not concentrated in a single location, but are distributed throughout the city. High-scoring segments can be found in West Philadelphia, Center City, Northwest Philadelphia, and Northeast Philadelphia.

Route-level score summaries and rankings

Since TSP investment decisions are commonly made at the transit route (rather than segment) level, DVRPC staff have also prepared a citywide route-level summary and ranking. This was accomplished by calculating the average segment score for all of the segments that each route traverses. Included in this analysis area is a total of 97 SEPTA routes, including trolley, trackless trolley, and bus routes. The range of scores is between 26.156 and 39.8, with a mean of 31.353. Figure 6 summarizes the top-10 ranked route-level TSP favorability scores, and includes a table identifying these routes. The range of these top scoring routes is from 34.234 and 39.8. Route 66 has a score approximately three points higher than any other route, likely because it travels along Frankford Avenue for the majority of the route, described earlier as one of the higher ranking arterials throughout the city in the one-mile segment analysis.

Another contributing factor may be passenger activity. Each of the top-10 routes have at least 5,000 or more passengers per day based on the 2012 APC data, led by Route 23 (running from South Philly to Chestnut Hill), with over 20,000 passengers on an average weekday. A table containing the full-ranked list of all routes in the citywide network can be found in Appendix A.


Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
PA
NJ
Delaware River
Schuylkill River
95
1
611
76
3
Figure 5:
TSP Favorability Score
16 - 25
26 - 28
29 - 31
32 - 35
36 - 45
Least Favorable
Most Favorable
N
0
1
2
Miles
dvrpc

Rank	Route	Mode	TSP Route Score
1	66	Trackless Trolley	39.80
2	16	Bus	36.81
3	56	Bus	36.43
4	18	Bus	35.03
5	22	Bus	34.98
6	80	Bus	34.98
7	21	Bus	34.86
8	23	Bus	34.61
9	44	Bus	34.43
10	9	Bus	34.23

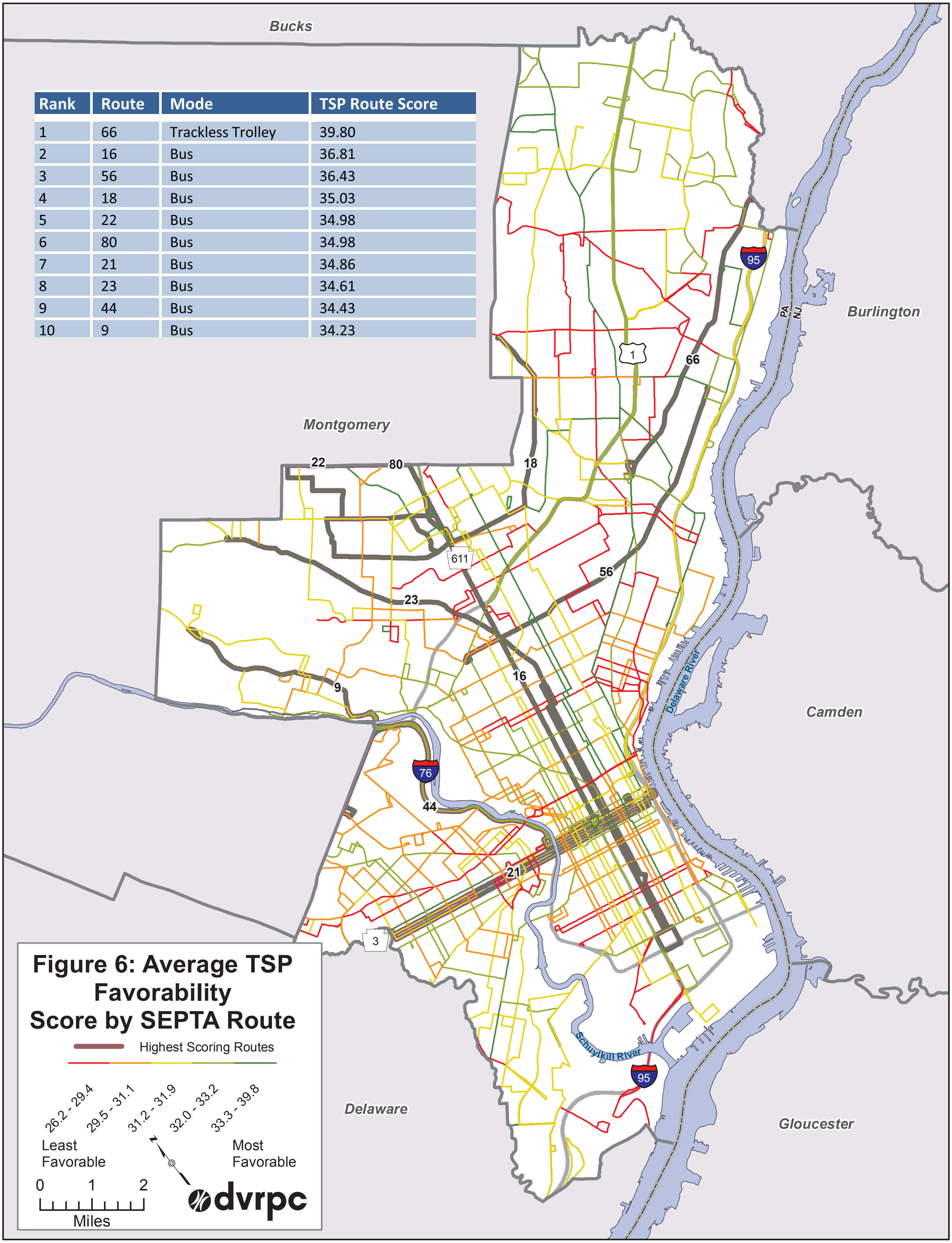


Figure 6: Average TSP Favorability Score by SEPTA Route

Chapter 3: Mercer County TSP Analysis and Results

Despite significant planning and both private and public investment, congestion threatens quality of life and limits future economic development in Mercer County. As a result, regional, county, and local stakeholders have pursued a series of planning efforts seeking ways to improve the linkages between transportation facilities and land development. This effort included the Mercer County Future Bus Plan (Publication 10035), prepared by DVRPC staff following significant input from local stakeholders. TSP was a key transit enhancement strategy emphasized in this plan and could be implemented along specific segments or entire corridors, granting buses extended green signal phases (or shortened red phases).

Mercer County Analysis Criteria

Similar to the Philadelphia analysis, a set of criteria was compiled to assess likely TSP effectiveness along corridors in Mercer County based on a review of industry best practices and available data sources. The inputs are intended to account for as many relevant factors as possible that would affect optimal TSP deployment. The TSP Favorability Score is a preliminary screening tool, and further review would be required prior to implementation to determine if a high scoring segment or corridor could truly be a successful location for TSP.

The raw data that was available for each criterion was reviewed, and following a review of the data's distribution, numerical values were grouped into bins to further organize the information and score each criterion. A consistent scoring framework made it possible to make an apples-to-apples comparison between criteria and aggregate them in an internally consistent way. The 11 criteria were divided into four categories: traffic, transit supply, transit demand, and planning priorities. A weighting scheme per category and per criterion was developed in consultation with the project's advisory committee to ensure that the criteria deemed most locally meaningful were given the greatest weight in the prioritization. Table 3 summarizes each of the criteria used in this analysis and their scoring. Detailed explanations of each criterion follow below. The farthest right column shows an example (Broad Street) of the highest scoring segment in Mercer County.

Traffic Criteria

The traffic set of criteria is intended to explore automobile traffic conditions in a prospective TSP corridor, and includes the following measures: V/C ratio, cross-street traffic volumes, and signal density. As a whole, the traffic category was weighted three out of the 10 total points in the composite scoring framework.

► The **volume-to-capacity (V/C)** ratio is a standard measure of roadway congestion. Peak-hour volume-to-capacity (V/C) ratios were calculated for the 2012 DVRPC Congestion Management Process (CMP) by using several years of recent traffic counts and roadway capacities derived from the DVRPC Regional Travel Demand Model. The traffic counts were converted from Average Annual Daily Traffic (AADT) counts to peak-hour volumes. Precise capacities are not available for all roads, so the Travel Demand Model capacities were used since they were sufficient for the regionally scaled CMP analysis. The literature suggests that TSP is most effectively applied where there is significant, but not debilitating, traffic congestion. Therefore, V/C ratios were grouped into a range of bins of <0.75, 0.75 to 1.25, and >1.25, with the middle bin being given the most favorable score.

► In addition to congestion levels along a corridor, it is also important to consider the implications for cross-streets. Mercer County stakeholders preferred to use cross-street volumes rather than cross-street V/C, as was used for Philadelphia. If cross-street characteristics are not effectively considered, TSP along a given corridor could be counterproductive—inappropriately benefiting one corridor at the expense of others. To account for this issue, it was important for the screening tool to evaluate a given corridor's characteristics in comparison to its cross-streets. To account for this, the average of **cross-street traffic volumes** was calculated using GIS. For higher average volumes, a lower (less favorable) score was assigned.

Table 3: Criteria for Mercer County TSP Screening Tool

	Criterion	Scoring Treatment	Weight	Score for Broad Street example segment (weighted score)
Traffic	Volume-to-capacity (V/C) ratio	1=low, 2.5=medium, 5=high; Mid-range = higher score	0.5	2.5 (1.25)
	Cross-street traffic volumes (average)	5 quantiles; Lower values = higher score	0.5	3 (1.5)
	Signal density	5 quantiles; Higher values = higher score	2.0	5 (10)
	Total for Traffic		**3.0**	**10.5 (12.75)**
Transit Supply	Transit vehicle volumes	5 quantiles; Higher values = higher score	1.0	5 (5)
	Peak transit vehicle volumes	5 quantiles; Higher values = higher score	1.0	5 (5)
	Location of stops	5 quantiles; More far-side stops = higher score	1.0	5 (5)
	Bus operations issues	1=No issues, 5=Congested areas; Higher value=higher score	1.0	5 (5)
	Total for Transit Supply		**4.0**	**20 (20)**
Transit Demand	Transit passenger volumes	5 quantiles; Higher values = higher score	2.0	5 (10)
	Total for Transit Demand		**2.0**	**5 (10)**
Planning Priorities	ICM	1=No, 5=Yes; Yes = higher score	0.25	5 (1.25)
	Functional class	5 categories; Higher class = higher score	0.5	4 (2)
	CMP corridor	1=No, 5=Yes; Yes = higher score	0.25	5 (1.25)
	Total for Planning Priorities		**1.0**	**14 (4.5)**
Total for All Criteria				**49.5 (47.25)**

Source: DVRPC 2013

▶ **Signal density** is a measure of the number of traffic signals per mile. In general, corridors with higher signal densities may lead to greater time savings from the application of TSP because transit vehicles are more likely to be impacted by signal delay. Therefore, a higher density of signals was awarded a higher score in the screening tool. Because this project used a network of same-length segments for analysis, signal count by segment was used as a proxy for density.

Transit Supply Criteria

The transit supply criteria are intended to reflect the level and characteristics of transit service in each corridor, and for Mercer County include the following measures: transit vehicle volumes, peak transit vehicle volumes, location of stops, and bus operations issues. The transit supply category was weighted four out of the 10 total points in the composite scoring framework.

▶ **Transit vehicle volumes** reflect the levels of transit service along a segment over a 24-hour period, whether provided via a single NJ Transit route or multiple routes that share a street segment. Higher volumes mean a higher number of scheduled transit runs that could benefit from TSP. As a result, higher volumes were awarded a higher score in the screening tool. This data was derived from NJ Transit General Transit Feed Specification (GTFS) schedule data as processed through the DVRPC Regional Travel Demand Model.

► **Peak transit vehicle volumes,** or just the levels of transit service along a segment during the morning and afternoon peak periods, were also included in the Mercer County analysis. In suburban locations, transit service is more concentrated during peak periods because of higher commuter usage. To amplify the presence of transit frequency during peak periods, the advisory committee thought that this addition would be particularly important. Similar to transit vehicle volumes, higher peak transit vehicle volumes result in higher scores in the screening tool.

► **Stop locations** are meaningful because far-side stops enhance TSP effectiveness (since intersection clearance times are more predictable). A higher percentage of far-side stops resulted in higher scores being assigned.

Source: DVRPC 2013

► New Jersey Transit staff were consulted about **bus operations issues** throughout the Mercer County bus network and indicated that there was concentrated congestion within the downtown Princeton and Trenton areas. Therefore, the segments that were within these two downtown areas were awarded higher scores in the screening tool.

Transit Demand Criteria

The transit demand criteria are intended to reflect actual passenger demand in a given corridor, or the number of individual transit riders who stand to benefit from TSP time savings. This set of criteria includes transit passenger volumes in Mercer County. The transit demand criteria category was weighted two out of the 10 total points in the composite scoring framework.

► **Transit passenger volumes** reflect transit ridership (boardings plus alightings) along a corridor, whether via a single NJ Transit route or multiple routes sharing a street segment. When transit passenger volumes are higher, more passengers demand service in that particular corridor, helping to justify investments like TSP to make service more efficient and reliable for active passengers and attractive to new passengers. Therefore, higher transit passenger volumes were awarded higher scores in the screening tool. Since stop-level data was not available, NJ Transit zone-level trip tables were converted to segment-level volumes in GIS.

Planning Priorities Criteria

This group of criteria builds upon prior work by DVRPC's Office of Transportation Operations Management and Office of Transportation Safety and Congestion Management. This category was weighted one out of the total 10 points in the composite scoring framework.

► **Integrated Corridor Management (ICM)** is a simple "yes or no" criteria determined by a TSP location falling into an ICM corridor, as identified in the DVRPC Transportation Operations Master Plan. ICM optimizes travel in a corridor by synchronizing traffic on expressways and arterials, as well as between highways and transit modes. The plan identifies potential corridors for ICM treatment. This is an established method that already has significance in the region; if a given segment is included in an ICM corridor, it was awarded a higher score.

► **Functional class** is based on the New Jersey Department of Transportation road classification system. For this category, five classes were used: local road, major collector, minor arterial, principal arterial, interstate/ freeway/ expressway. In general, investments are likely to be made on higher classification roadways. Therefore, the higher roadway classification was awarded a higher score in the screening tool.

► The DVRPC **Congestion Management Process (CMP)** is a systematic process to minimize congestion and enhance the ability of people and goods to reach their destinations. The CMP advances the goals of the DVRPC Long-Range Plan and strengthens the connection between the plan and the regional Transportation Improvement Program (TIP). With input from its advisory committee, the CMP identifies congested corridors and multimodal strategies to mitigate congestion for all locations in the region. The most recent CMP update was published in 2012. Segments of CMP corridors identified as more congested in the 2012 CMP were given higher scores in the screening tool.

Evaluation Process and Analysis

Once the scoring framework was established, the inputs were analyzed in GIS to create a composite TSP Favorability Score. The data for each criterion was mapped to a network of one-mile segments that consisted of each signalized roadway. The TSP Favorability Score is an overall approximation of the locations where TSP is likely to be most successful, considering a segment's overall transit and transportation context. Mercer County is interested in the TSP Favorability Score as a tool to inform the implementation of TSP on portions or the entirety of existing and planned bus routes (proposed in the *Mercer County Future Bus Plan*) within the county. Therefore, in addition to scoring the existing bus routes, scoring was also completed for the planned bus routes recommended in the *Mercer County Future Bus Plan*.

This section details the process used to calculate the TSP Favorability Score. Since the road segments that have planned bus service do not have transit activity currently, only the traffic and planning priorities criteria are awarded scores higher than zero for those segments.

Once all of the criteria were mapped and their numerical values were assigned to segments across the network, each segment was assigned scores for each criterion according to the scoring and weighting framework summarized in Table 3. These criteria-level scores were then added to create the composite TSP Favorability Score for each segment. The highest possible TSP Favorability Score that a segment could achieve was 50. The *Mercer County Future Bus Plan* project established the network, and this study can build off this network and be used as a guideline for Mercer County and NJ Transit to select the locations, technology, and routes that will be most useful for the implementation of TSP.

TSP Favorability Score Results

Conducting the analysis using a network of signalized one-mile road segments allows corridors to be compared at various levels of granularity. For example, segment-level scores can be averaged for a longer segment or a given transit route, enabling apples-to-apples route-level comparisons. Figure 7 summarizes the distribution of county-wide existing bus service segment-level TSP Favorability Scores in a histogram. The range of scores is between 11.25 and 47.25, where the mean is 24.62.

Table 4 exhibits the top-10 scoring road segments that have existing bus service. Nine out of 10 of them are within the City of Trenton, and number eight is in Hamilton Township. Figure 8 maps the road segments with existing service and summarizes their TSP Favorability Scores in colorscale, and the planned routes in grayscale. The majority of road segments with a high Favorability Score are around Trenton and have service into Hamilton, Ewing, and Lawrence townships, and in the Princeton area.

Figure 7: TSP Favorability Score Histogram for Mercer County Existing Routes

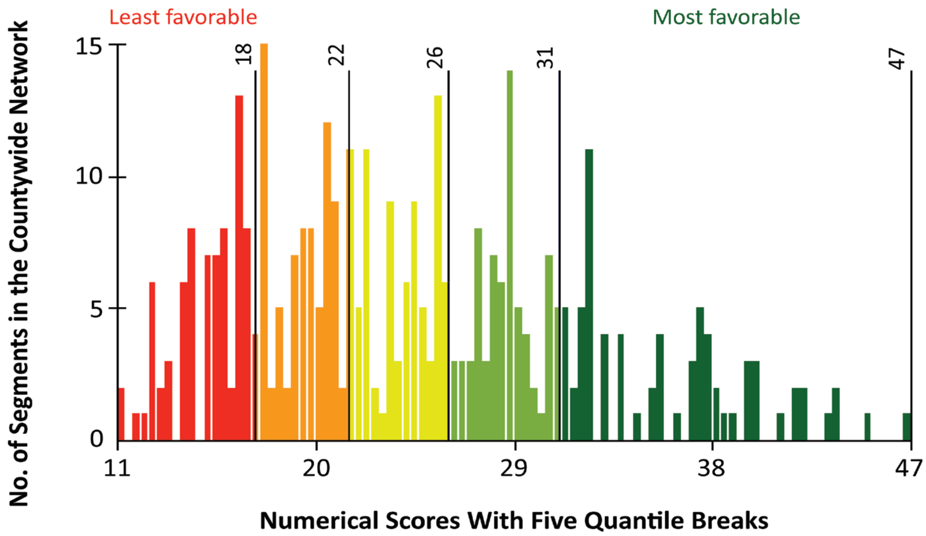


Table 4: Top-10 TSP Favorability Score Segments with Existing Bus Service

Rank	Bus Routes	TSP Score	Street Segment	City
1	409, 600, 602, 603, 604, 607, 611, 613	47.25	Broad Street between State Hwy. 33 and Old Rose St.	Trenton
2	409, 418, 600, 602, 603, 604, 607, 611, 613	45.25	Martin Luther King, Jr. Boulevard between Broad Street and Sanford St.	Trenton
3	409, 603, 607, 613	44.00	Broad Street between Irving Pl. and Lalor St.	Trenton
4	409, 418, 604, 608, 611	43.75	State Street between Clinton Ave. and Olden Ave.	Trenton
5	409, 418, 600, 601, 606, 608, 609, 611, 619	43.50	Clinton Avenue between Mott St. and Model Ave.	Trenton
6	409, 418, 600, 601, 606, 608, 609, 611, 619	42.25	State Street between Montgomery St. and Clinton Ave.	Trenton
7	418, 601, 606, 608, 609, 619,	42.25	State Street between US 1 (Trenton Fwy.) and Green Pl.	Trenton
8	409, 603, 607, 613	42.00	Broad Street between Maddock Ave. and Lily St.	Hamilton
9	600, 602, 604, 611	42.00	Perry Street between Clinton Ave. and Martin Luther King, Jr. Blvd.	Trenton
10	409, 600, 602, 611	41.25	Front Street between Stockton St. and US 1 (Trenton Fwy.)	Trenton

Source: DVRPC 2013

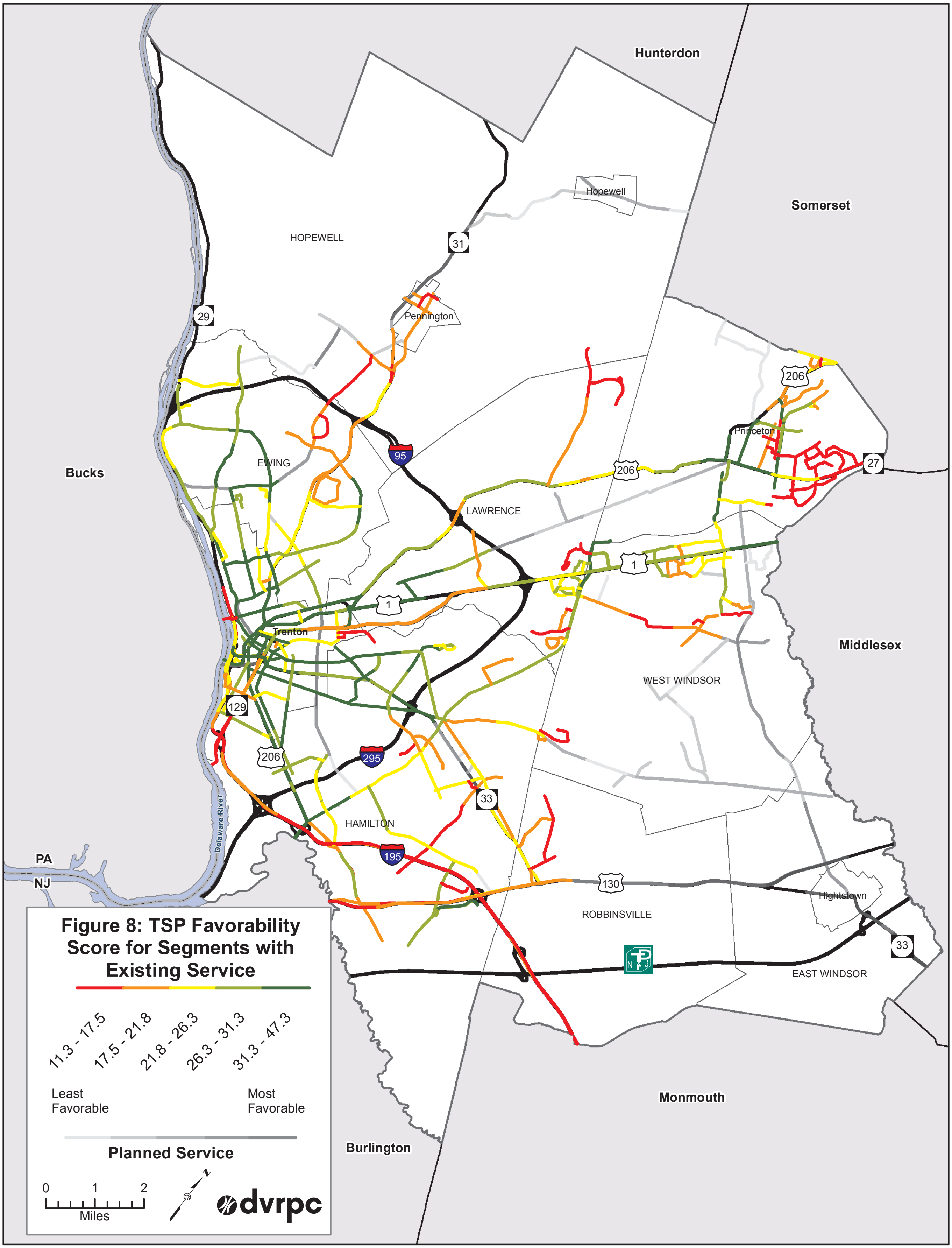


Figure 8: TSP Favorability Score for Segments with Existing Service

A second component of the analysis in Mercer County was preparing a TSP Favorability Score for road segments with planned service. Figure 9 shows a distribution for these segments. The scores range from 11.25 to 27.25, with a mean of 16.6. Table 5 displays the top-10 ranked planned segments. Among the higher-rated road segments are those proposed within East Windsor, West Windsor, and Trenton.

Figure 9: TSP Favorability Score Histogram for Mercer County Planned Routes

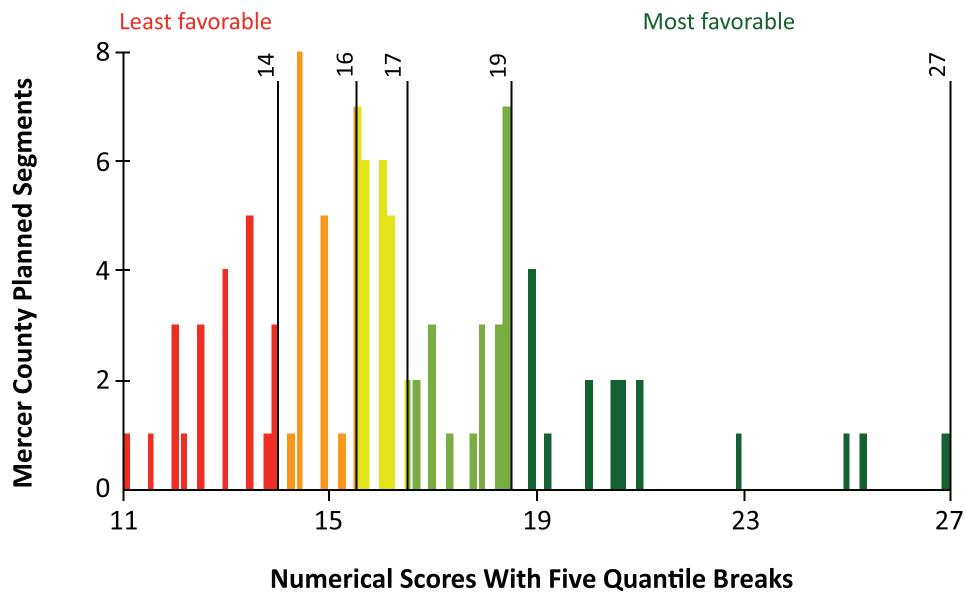


Table 5: Top-10 TSP Favorability Score Segments with Planned Bus Service

Rank	TSP Score	Street Name	City
1	27.25	West Hanover Street between Prospect St. and Martin Luther King Jr., Blvd.	Trenton
2	25.5	US 130 between Dutch Neck Rd. and Thomas St.	East Windsor
3	25.25	Olden Avenue between Partridge Ave. and Ward Ave.	Trenton/ Hamilton border
4	23.25	Armory Drive, E. Front Street, Merchant Street, W. Canal Street (loop from S. Stockton St.)	Trenton
5	21.25	Franklin Street (Eastbound) between Twin Rivers Dr. and Monmouth St.	East Windsor
6	21.25	Franklin Street (Westbound) between Twin Rivers Dr. and Davidson Rd.	East Windsor
7	21.0	Olden Avenue between Parker Ave. and Ellis Ave.	Trenton
8	21.0	Scotch Road between Nursery Rd. and County Hwy. 546	Hopewell
9	20.75	Princeton Highstown Rd. (Route 571) between One Mile Rd. and Highstown Bypass 133	East Windsor
10	20.75	Princeton Hightstown Road between S. Mill Rd. and Sherbrooke Dr.	West Windsor

Source: DVRPC 2013

Since TSP investment decisions are commonly made at the transit-route level (rather than segment), DVRPC staff have also prepared a county-wide route-level summary and ranking. This was accomplished by calculating the average segment score for all of the segments that each route traverses. Table 6 shows the 20 NJ Transit bus routes within Mercer County.

Table 6: TSP Favorability Scores for NJ Transit Routes

Rank	Route	TSP Score	Terminal	Terminal
1	409	38.30	Trenton Transit Center	Philadelphia
2	608	35.48	Hamilton Township	West Trenton
3	611	34.72	Trenton Transit Center	Trenton River View Plaza
4	609	34.55	Ewing Township	Lawrence Township
5	619	33.75	Ewing Township	Lawrence Township
6	604	33.02	East Trenton	Trenton Transit Center
7	655	31.98	Princeton Township	Plainsboro Township
8	607	31.40	Ewing Township	Hamilton Township
9	601	31.11	Ewing Township (TCNJ)	Hamilton Township
10	603	30.79	Lawrence Township	Hamilton Township
11	613	30.52	Lawrence Township (Mercer Mall, Lawrence Center)	Hamilton Marketplace
12	606	29.05	Princeton Township (Princeton Care Center)	Robbinsville
13	418	29.03	Trenton Transit Center	Camden (Walter Rand Transportation Center)
14	600	26.88	Trenton Transit Center	Princeton
15	605	26.88	Montgomery Township	Lawrence Township
16	602	24.46	Pennington	East Trenton
17	610	24.06	Trenton High School	John Witherspoon School
18	612	21.12	Lawrence Township	Princeton Junction
19	308	16.21	Jackson Township	New York (42nd Street Bus Terminal)
20	318	16.14	Philadelphia (Greyhound Station)	Jackson Township

Source: DVRPC 2013

Figure 10 is a map of all planned bus routes recommended in the Mercer County Future Bus Plan (DVRPC Publication # 10035). This includes all road segments that have planned service or road segments where planned service shares alignment with existing service. Figure 11 illustrates TSP Favorability Scores, in the colored scale for road segments that have only planned bus service (while segments that also have existing service are shown in grayscale). The road segments that score well in Figure 11 are scattered throughout the county. In comparing Figures 10 and 11, it can be concluded that each of the following planned bus routes has at lease one segment within the highest quantile for the TSP Favorability score.

- Route 656: Monroe to Princeton Junction and Quaker Bridge Mall.
- BRT Link 1: Hamilton Park to I-95/Reed Road transit hub.

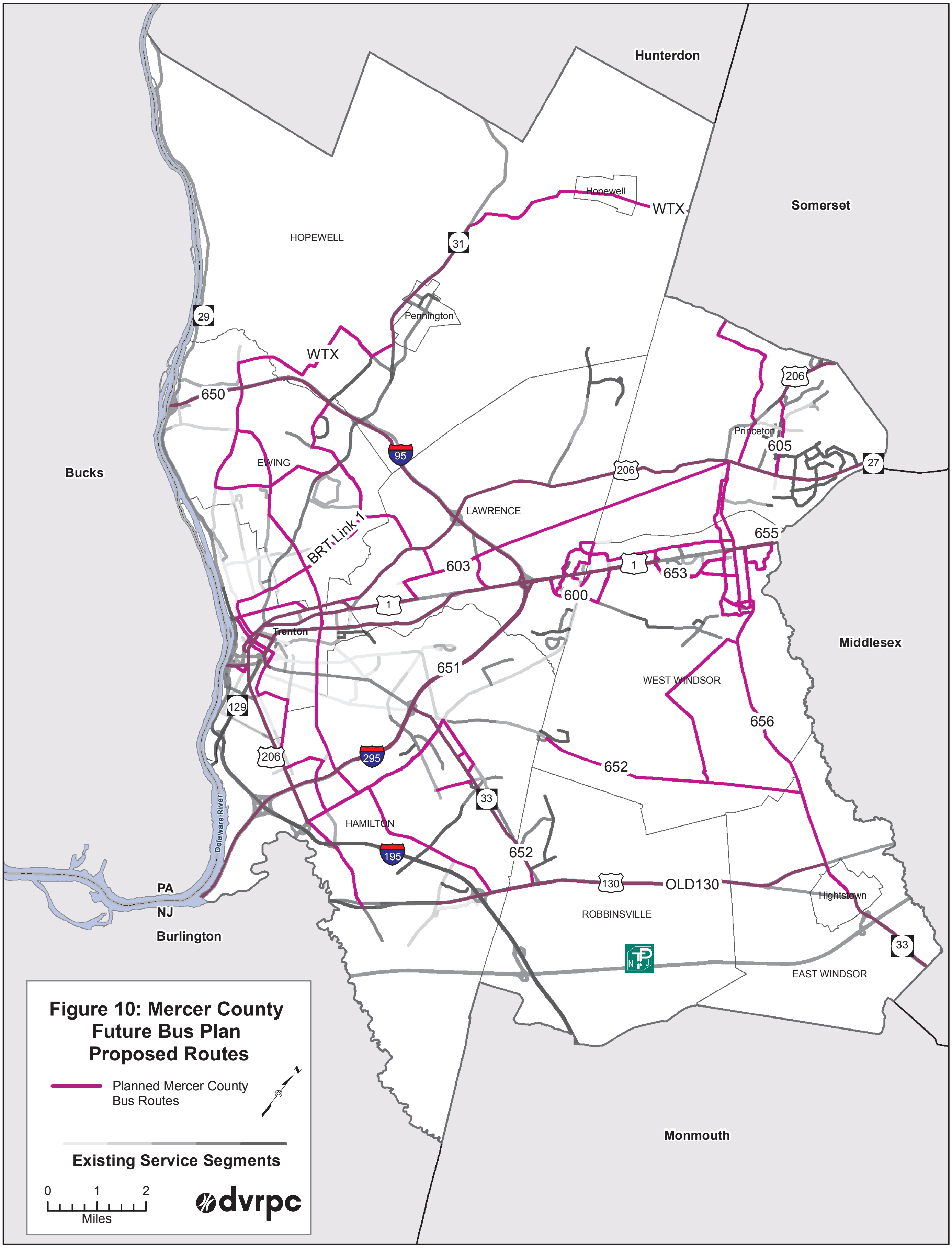
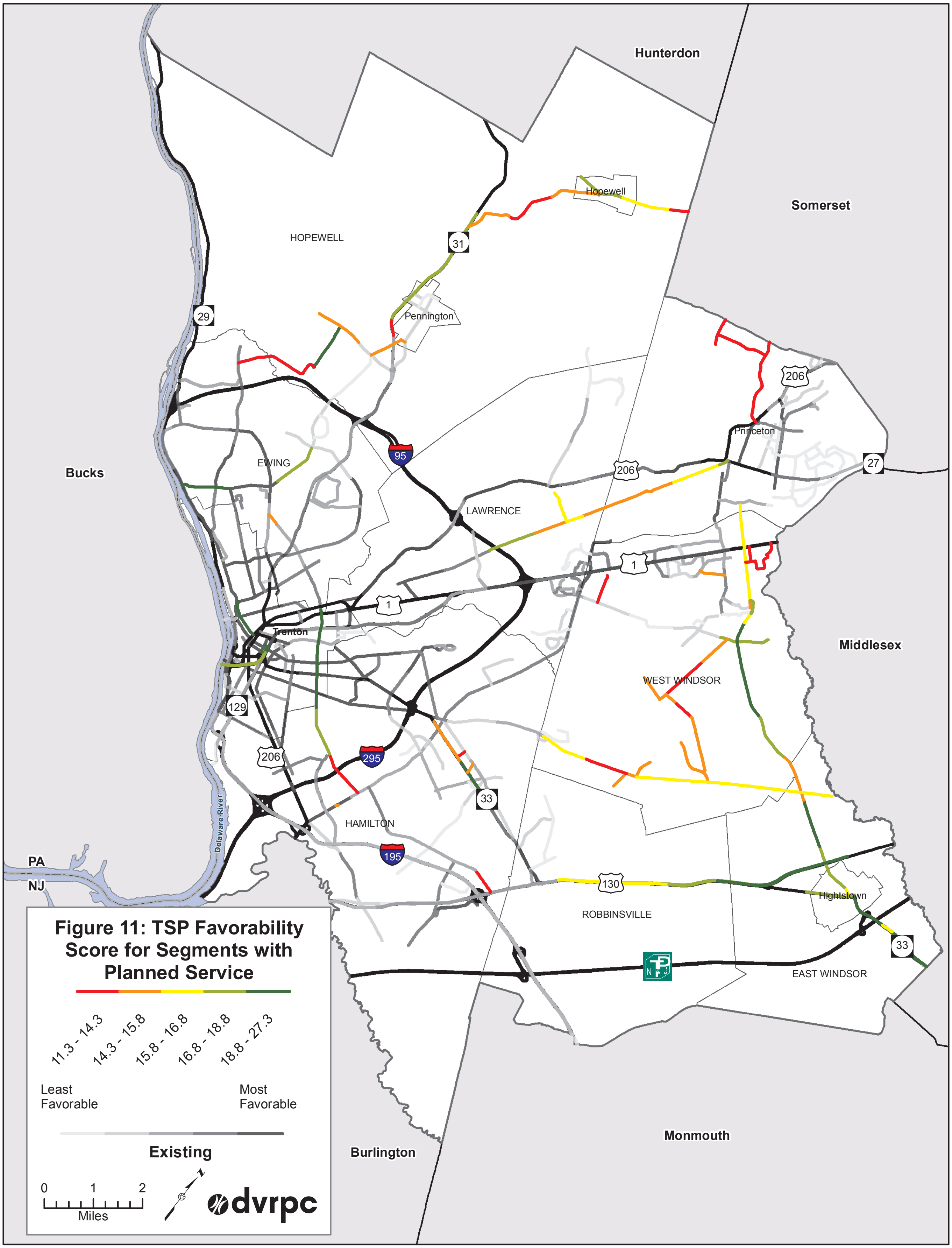


Figure 10: Mercer County Future Bus Plan Proposed Routes


Hunterdon
Somerset
Bucks
Middlesex
Monmouth
Burlington
PA
NJ
HOPEWELL
Hopewell
Pennington
EWING
LAWRENCE
Princeton
Trenton
WEST WINDSOR
HAMILTON
ROBBINSVILLE
Hightstown
EAST WINDSOR
Delaware River
31
29
95
206
27
1
129
295
33
195
130
Figure 11: TSP Favorability Score for Segments with Planned Service
11.3 - 14.3
14.3 - 15.8
15.8 - 16.8
16.8 - 18.8
18.8 - 27.3
Least Favorable
Most Favorable
Existing
0
1
2
Miles
dvrpc

- Route 603/613: Carnegie Center/Princeton Junction to Hamilton Marketplace.
- Route 652: Edgebrook/US 130 to Princeton.
- OLD130: W. Trenton-Hamilton-Highstown-Twin Rivers: Olden Ave and US 130.
- WTX: West Trenton Station-Pennington-Hopewell.
- Route 650: Lower Bucks County park-and-rides to Plainsboro.

APPLICATIONS AND FUTURE WORK

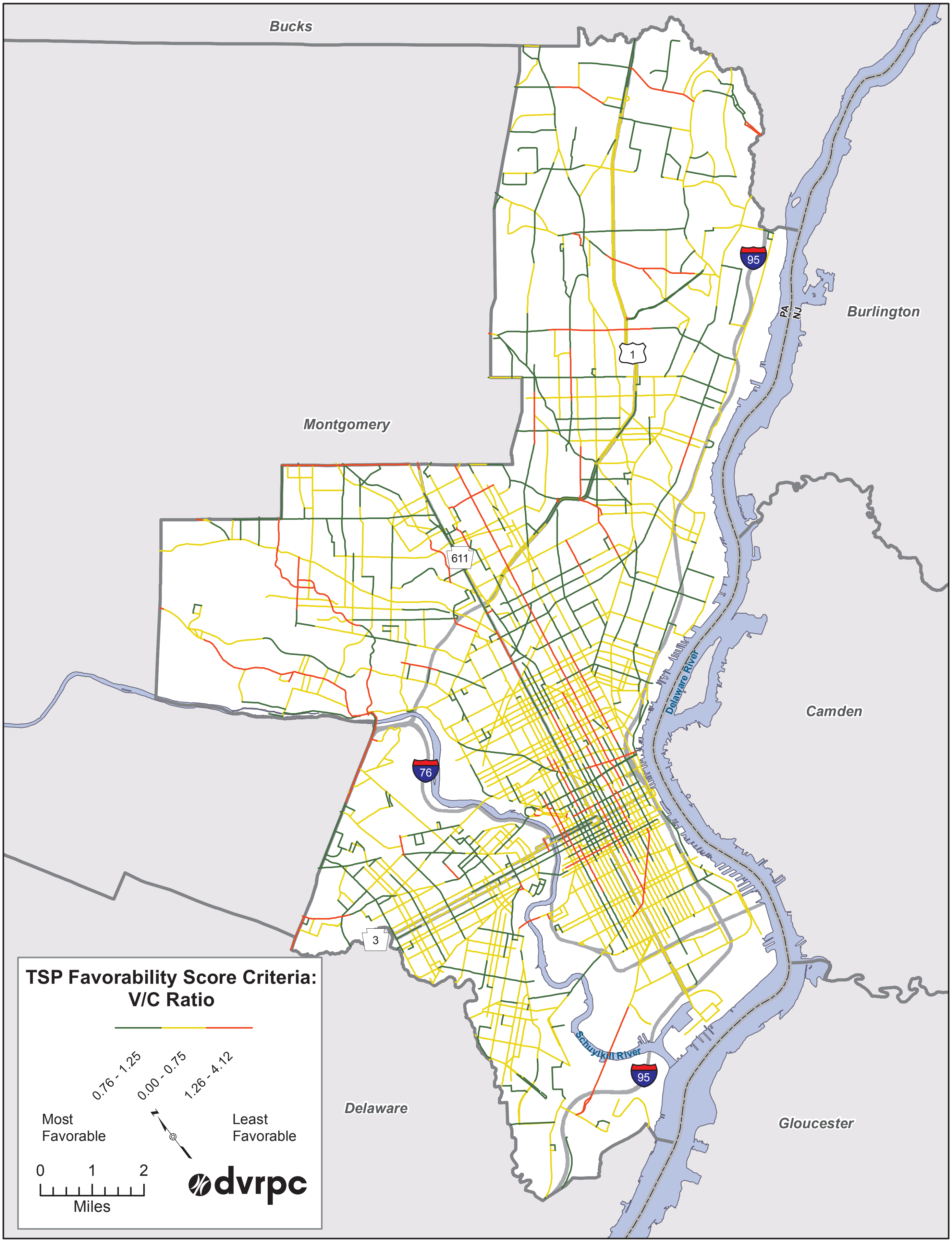
This project was intended to assemble a set of factors to evaluate the likely effectiveness of TSP investments considering a wide range of industry best practice criteria. The screening tool that was developed is intended to be used (with locally appropriate modifications to criteria, scoring, or weights) for a range of future regional and national applications.

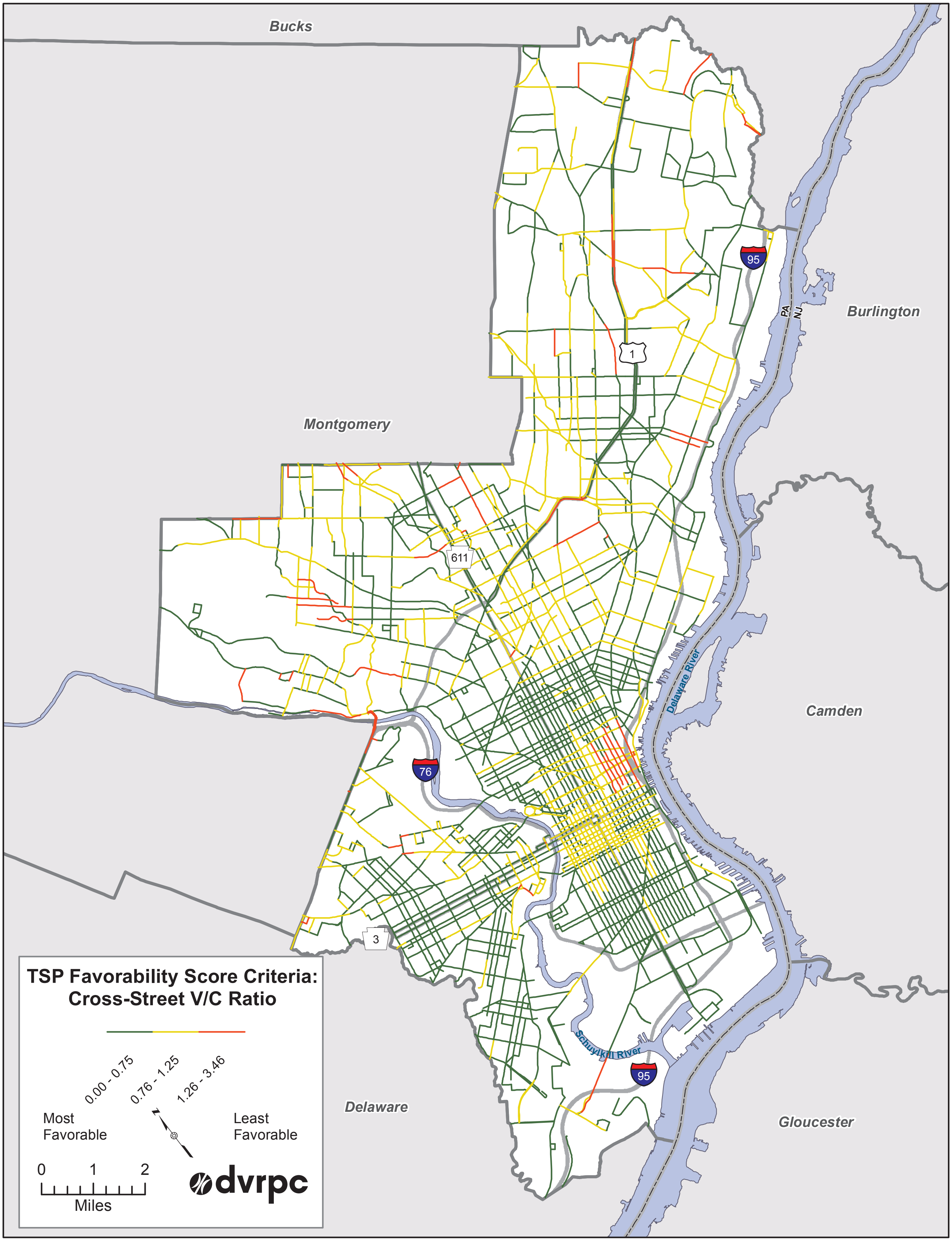
As additional TSP investments are made in the DVRPC region over the next several years, it will be important to assess the time savings that are achieved in comparison with each project's TSP Favorability Score in order to make further refinements to the screening tool.

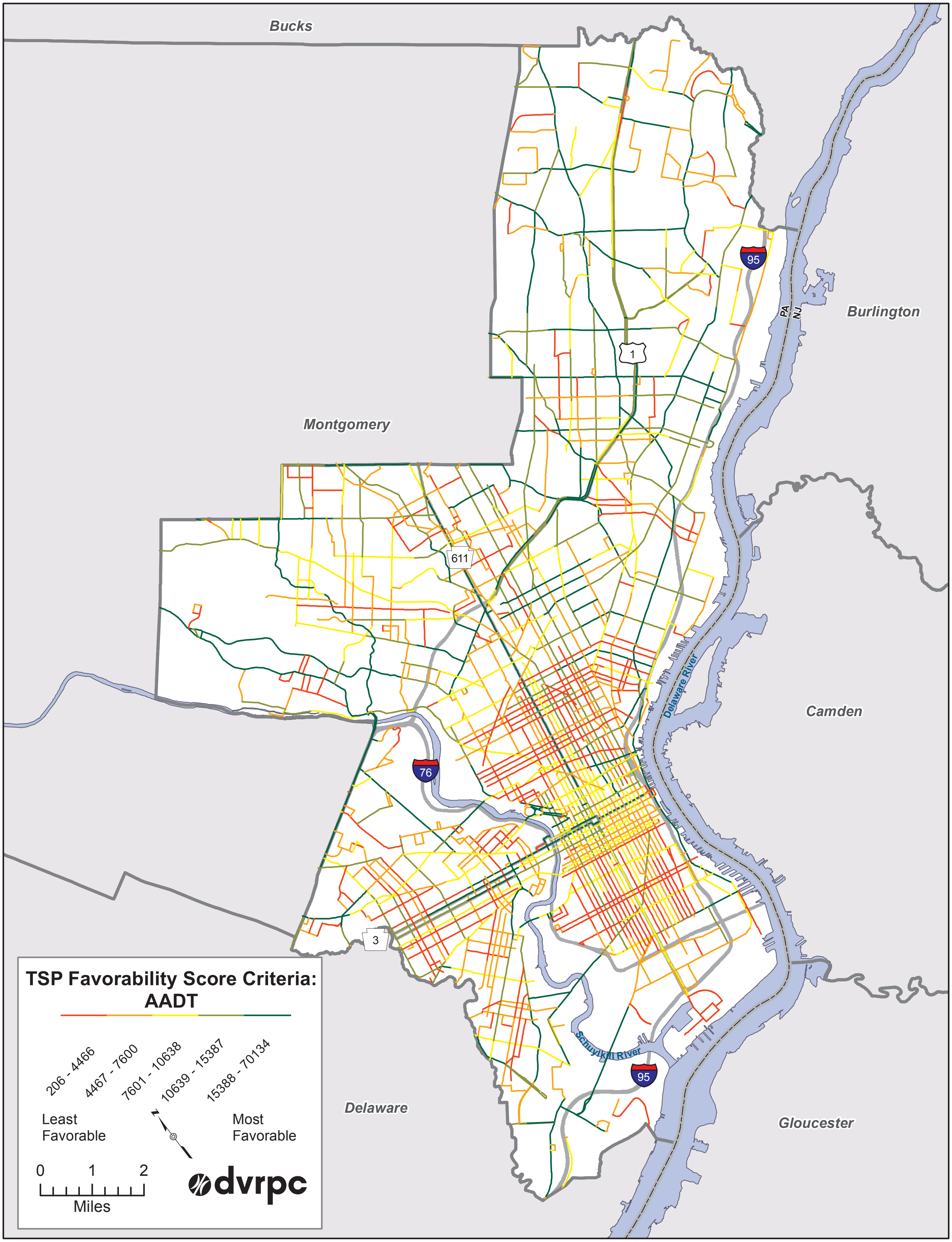
Appendix A

Philadelphia Criterion Maps

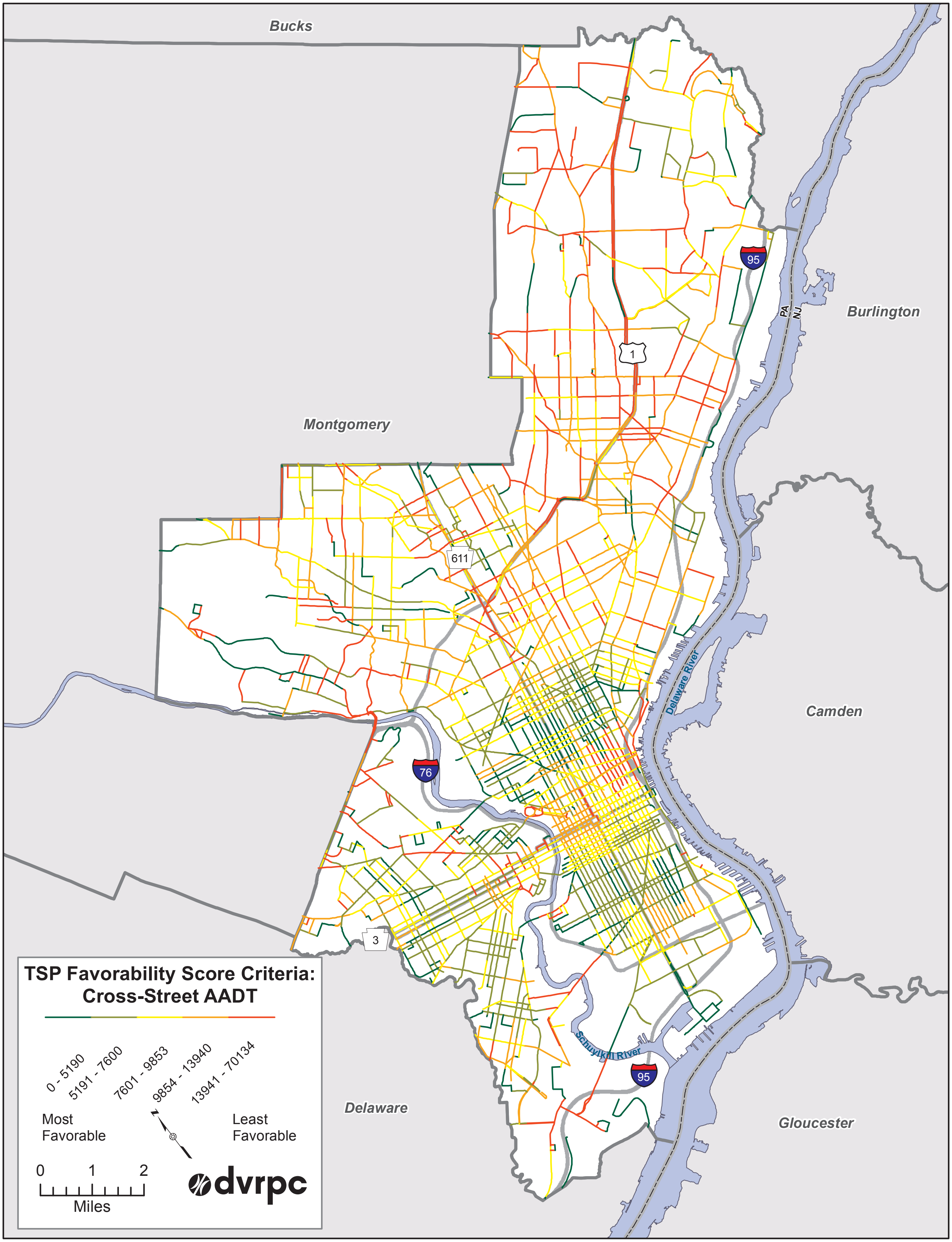
Appendix A is a succession of maps illustrating how each segment in Philadelphia scored by criterion. Please refer to Table 2 on page 12 for more details regarding scoring and weight of each criterion.

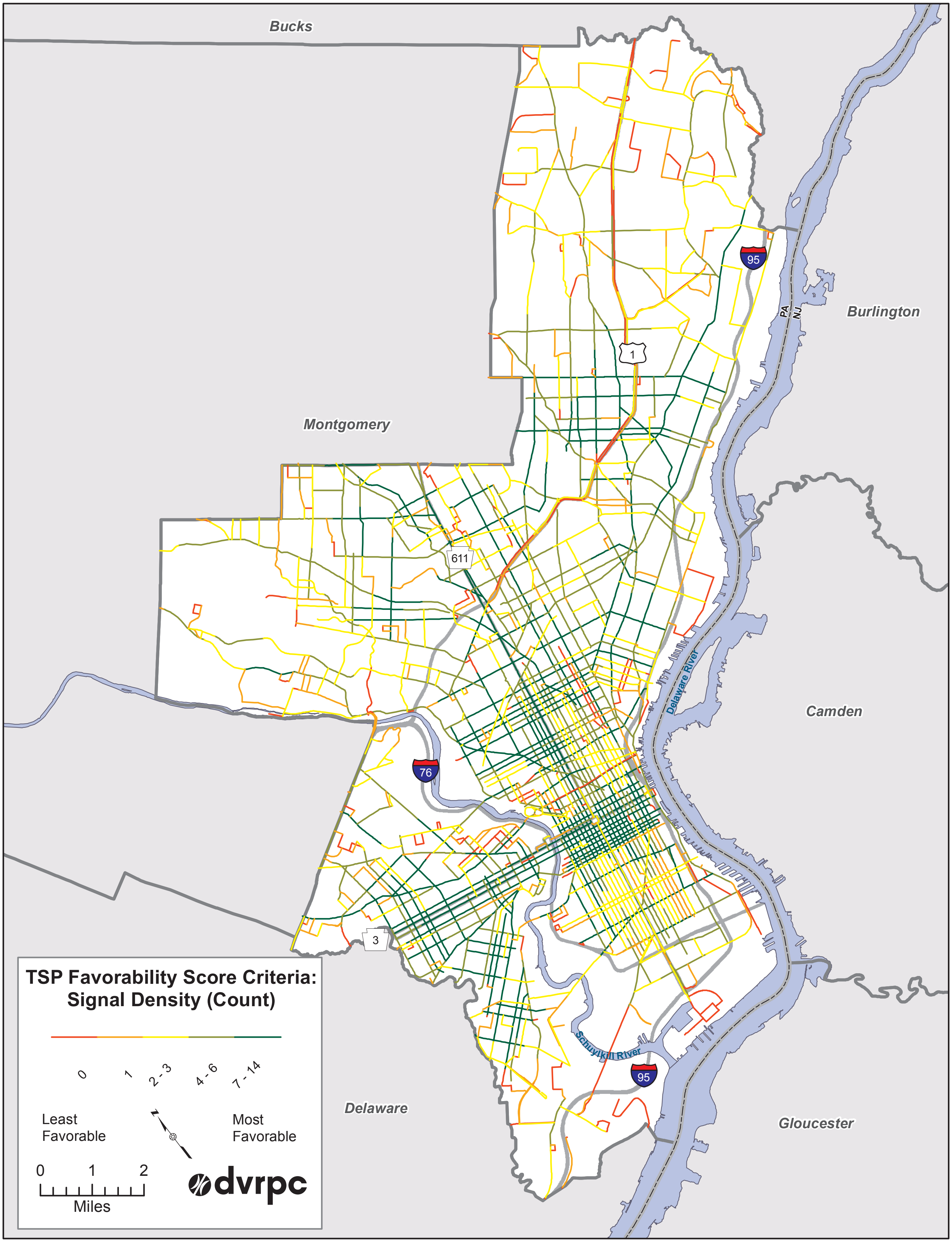

Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
PA
NJ
Delaware River
Schuylkill River
95
1
611
76
3
TSP Favorability Score Criteria:
V/C Ratio
0.76 - 1.25
0.00 - 0.75
1.26 - 4.12
Most
Favorable
Least
Favorable
N
0
1
2
Miles
dvrpc

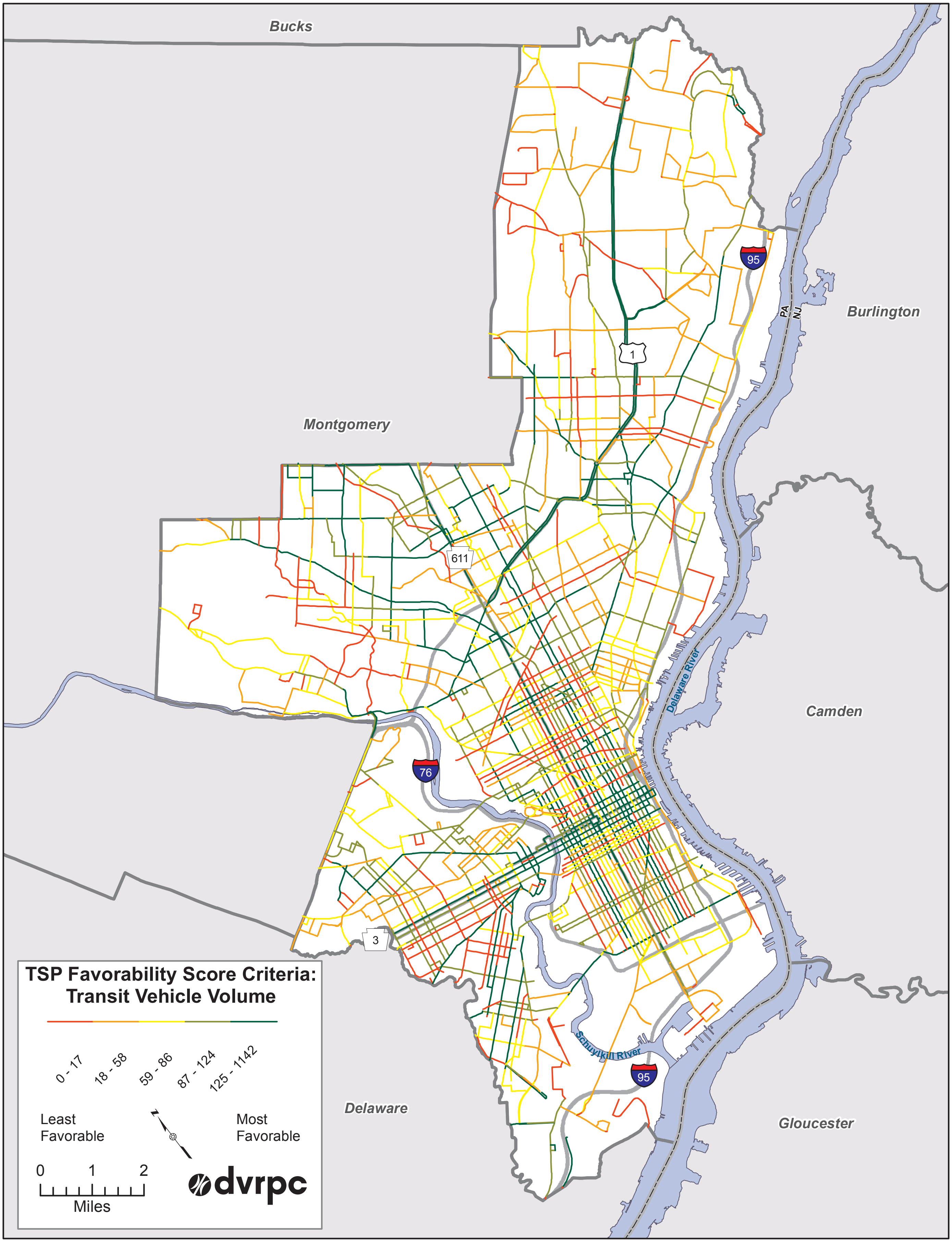

Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
Delaware River
Schuylkill River
PA
NJ
95
1
611
76
3
95
TSP Favorability Score Criteria: Cross-Street V/C Ratio
0.00 - 0.75
0.76 - 1.25
1.26 - 3.46
Most Favorable
Least Favorable
0 1 2
Miles
dvrpc

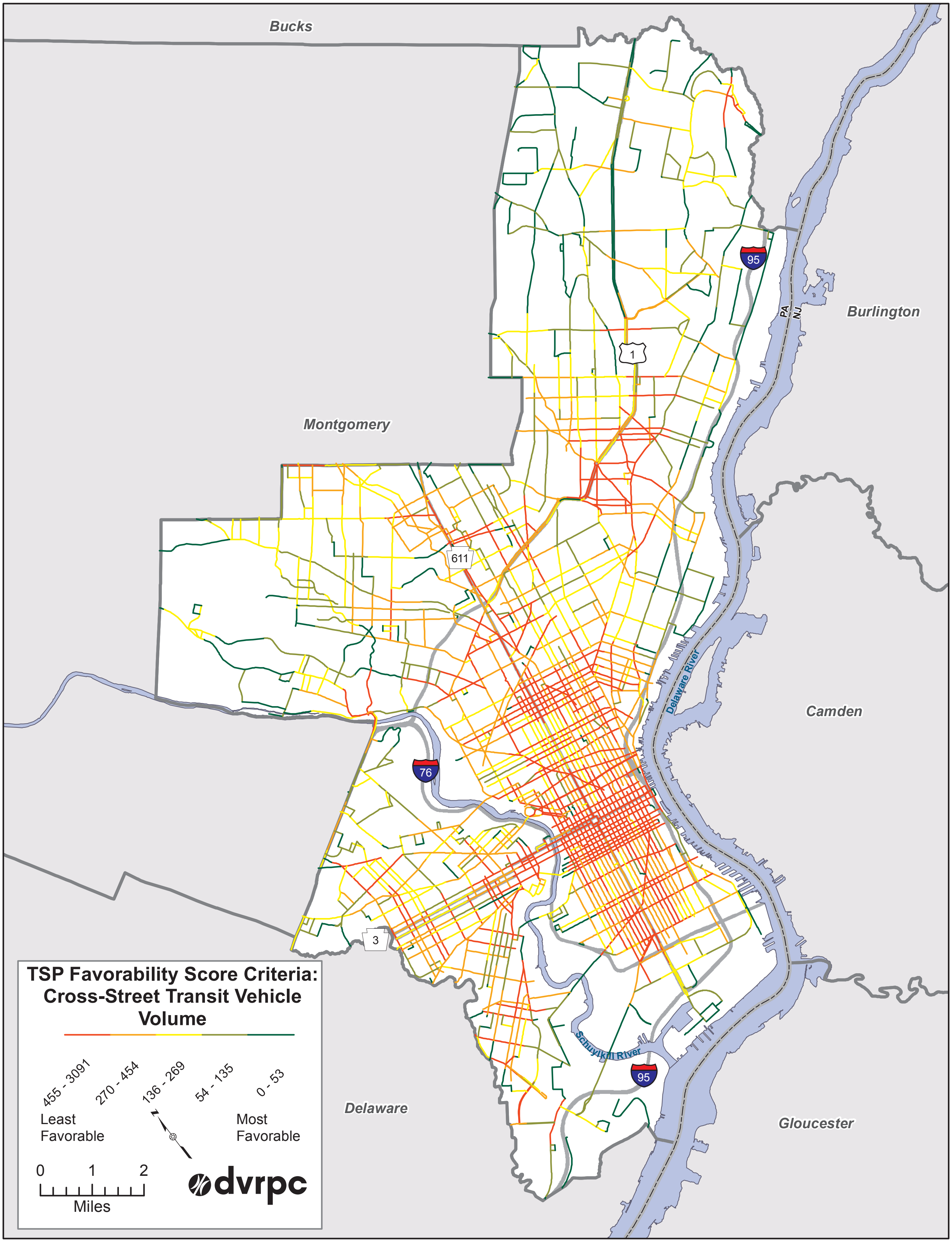


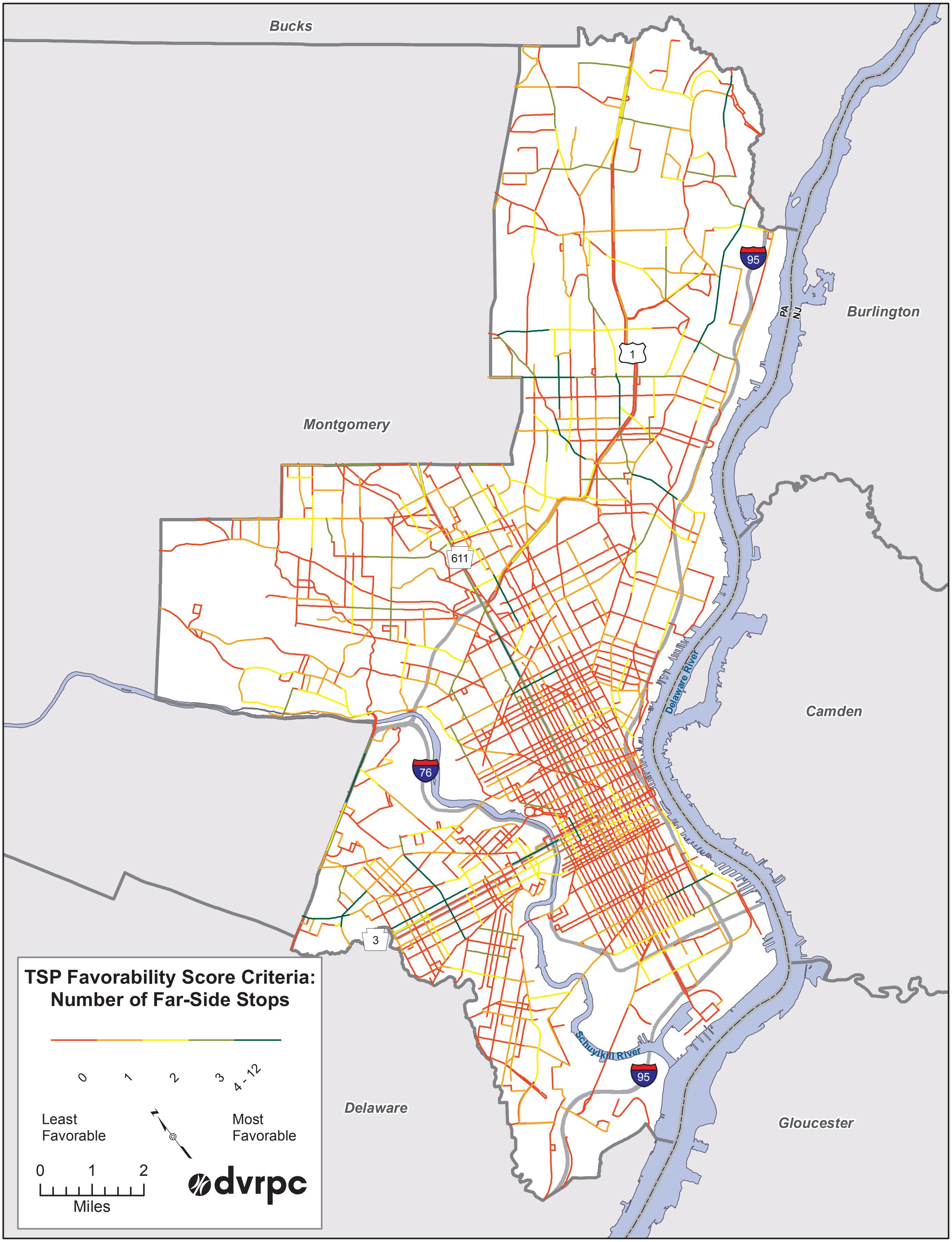
Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
PA
NJ
Delaware River
Schuylkill River
95
1
611
76
3
TSP Favorability Score Criteria:
AADT
206 - 4466
4467 - 7600
7601 - 10638
10639 - 15387
15388 - 70134
Least Favorable
Most Favorable
N
0
1
2
Miles
dvrpc

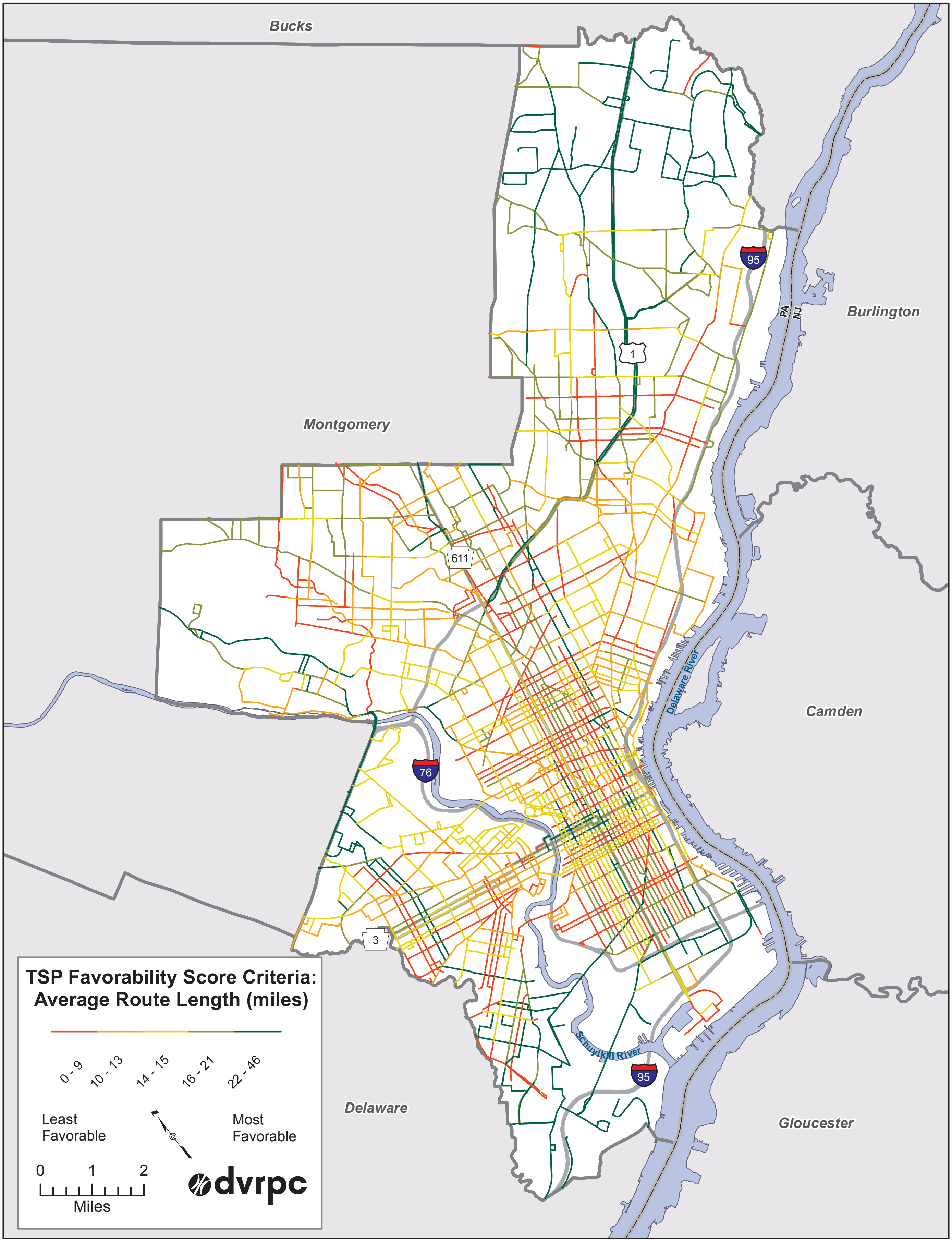

Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
PA
NJ
Delaware River
Schuylkill River
95
1
611
76
3
TSP Favorability Score Criteria: Cross-Street AADT
0 - 5190
5191 - 7600
7601 - 9853
9854 - 13940
13941 - 70134
Most Favorable
Least Favorable
0 1 2
Miles
dvrpc

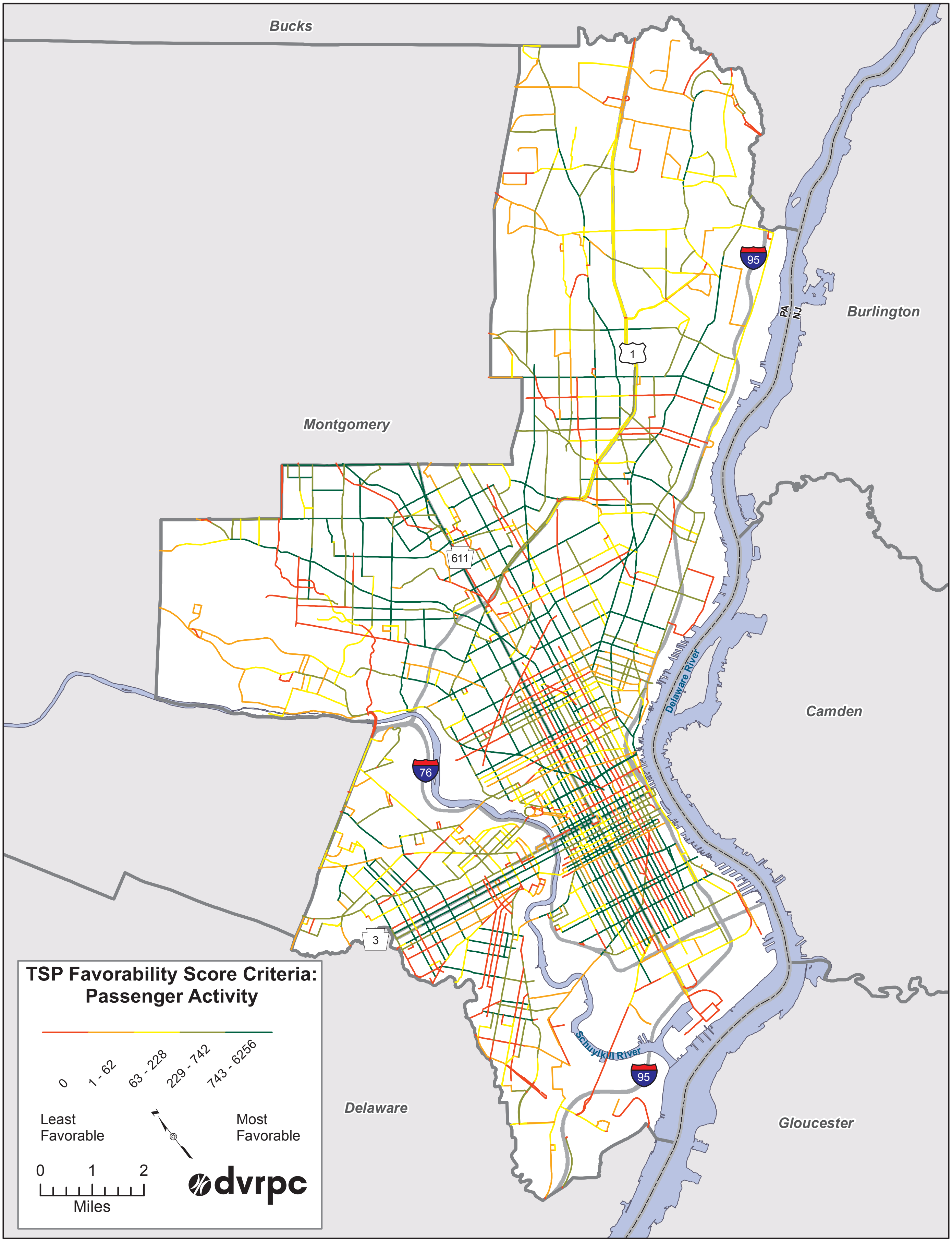

Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
Delaware River
Schuylkill River
PA
NJ
95
1
611
76
3
95
TSP Favorability Score Criteria: Signal Density (Count)
0
1
2 - 3
4 - 6
7 - 14
Least Favorable
Most Favorable
N
0 1 2
Miles
dvrpc

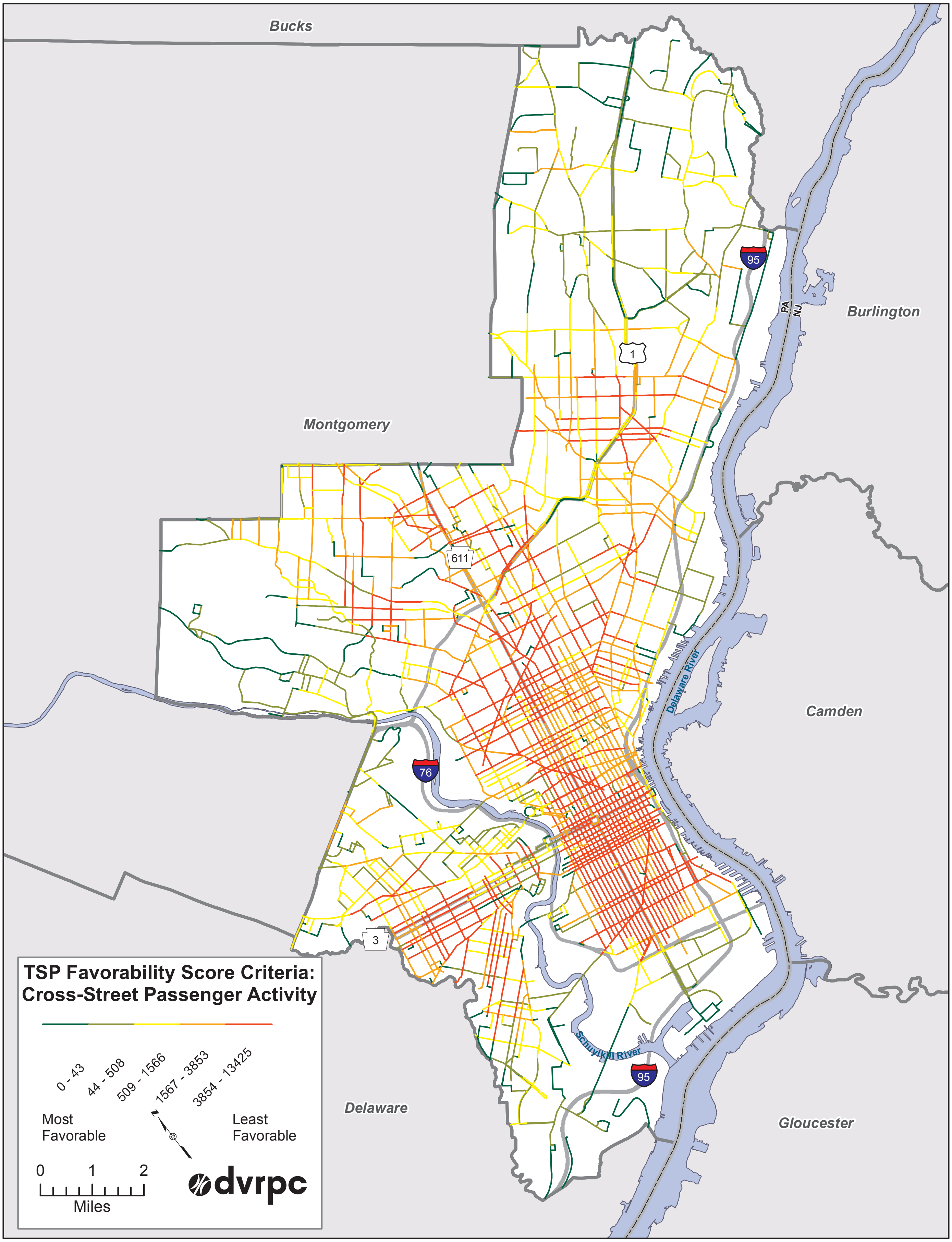

Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
PA
NJ
Delaware River
Schuylkill River
95
1
611
76
3
TSP Favorability Score Criteria:
Transit Vehicle Volume
0 - 17
18 - 58
59 - 86
87 - 124
125 - 1142
Least Favorable
Most Favorable
N
0
1
2
Miles
dvrpc

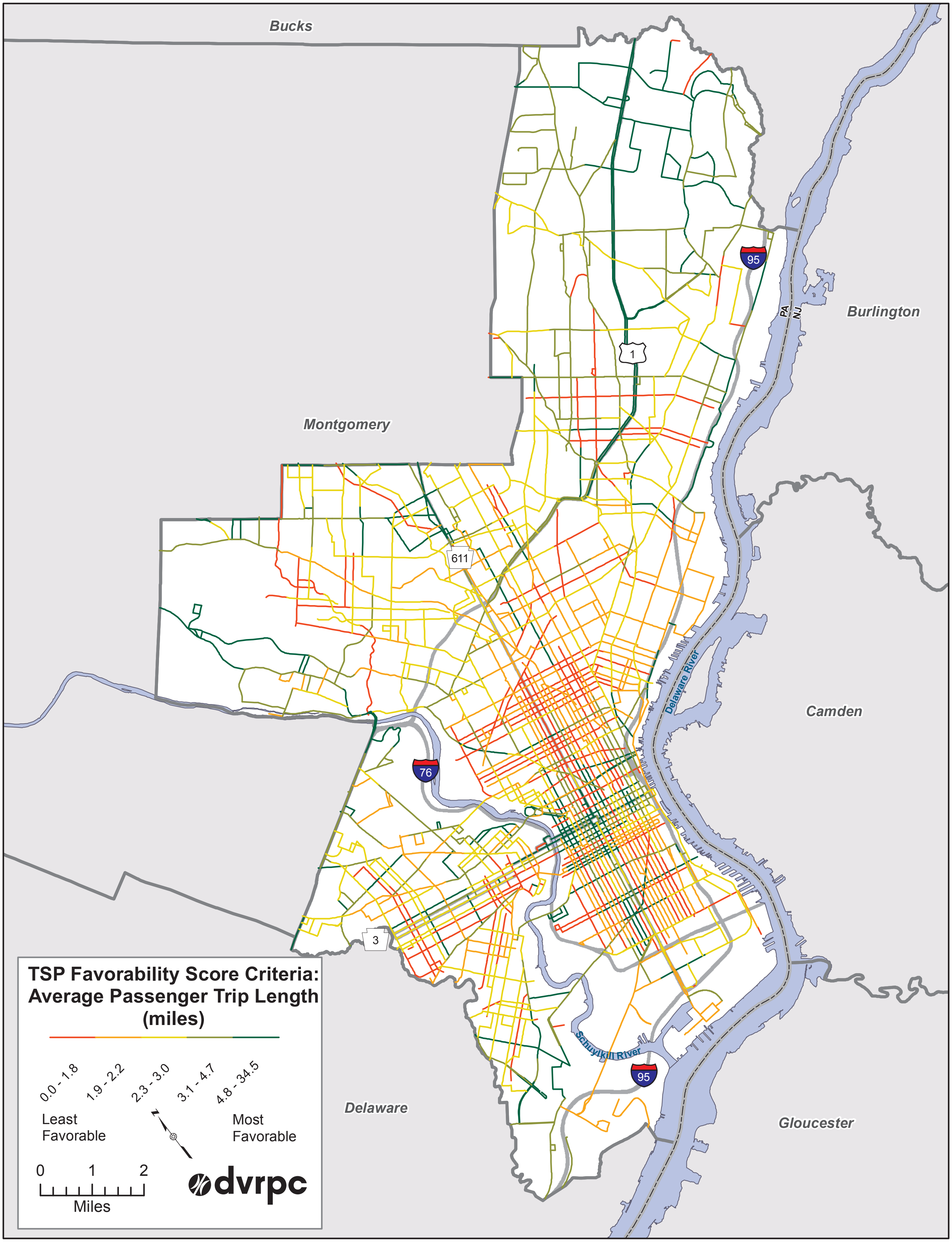

Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
Delaware River
Schuylkill River
PA
NJ
95
1
611
76
3
TSP Favorability Score Criteria: Cross-Street Transit Vehicle Volume
455 - 3091
270 - 454
136 - 269
54 - 135
0 - 53
Least Favorable
Most Favorable
0 1 2
Miles
dvrpc

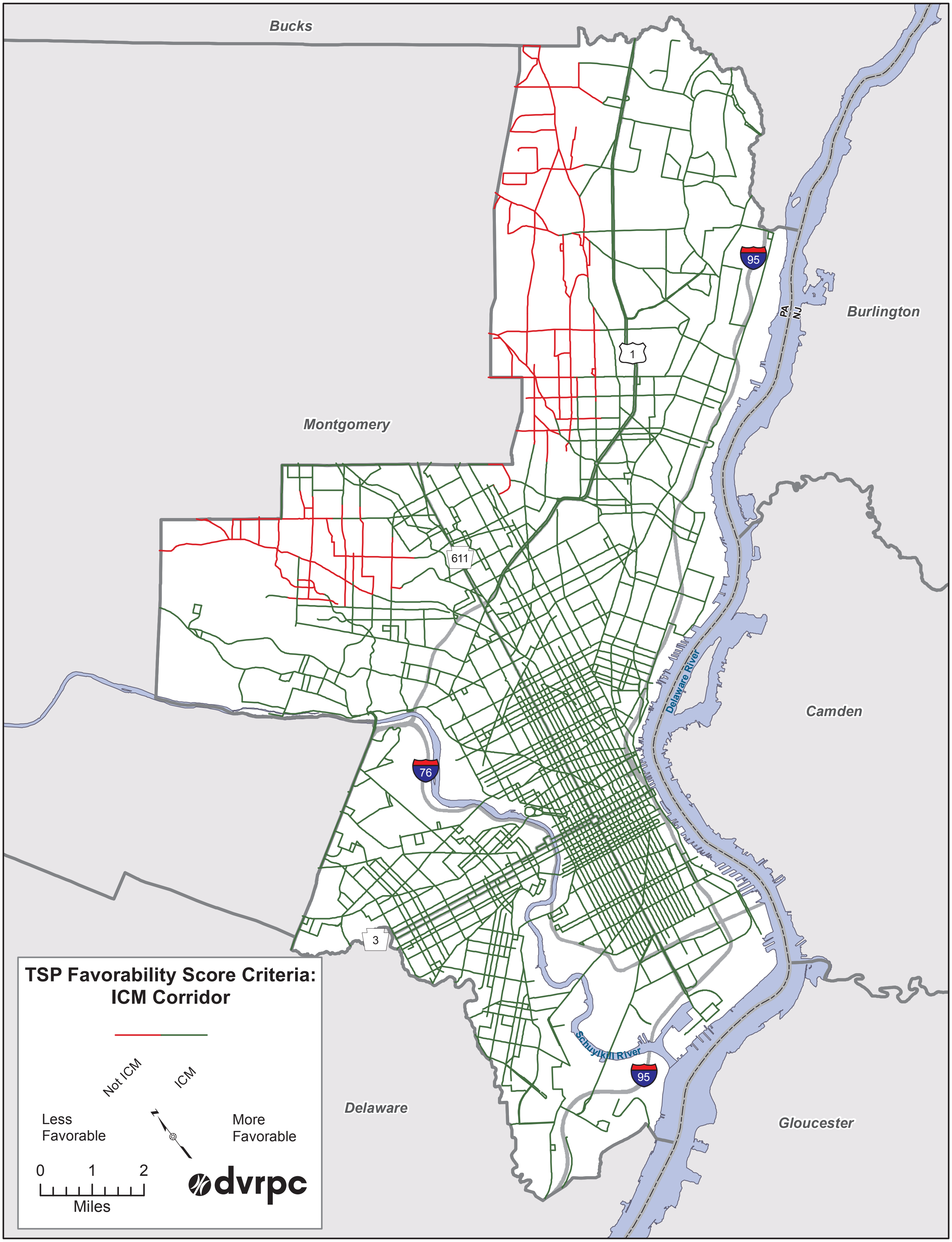

Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
PA
NJ
Delaware River
Schuylkill River
95
1
611
76
3
95
TSP Favorability Score Criteria:
Number of Far-Side Stops
0
1
2
3
4 - 12
Least Favorable
Most Favorable
0
1
2
Miles
dvrpc

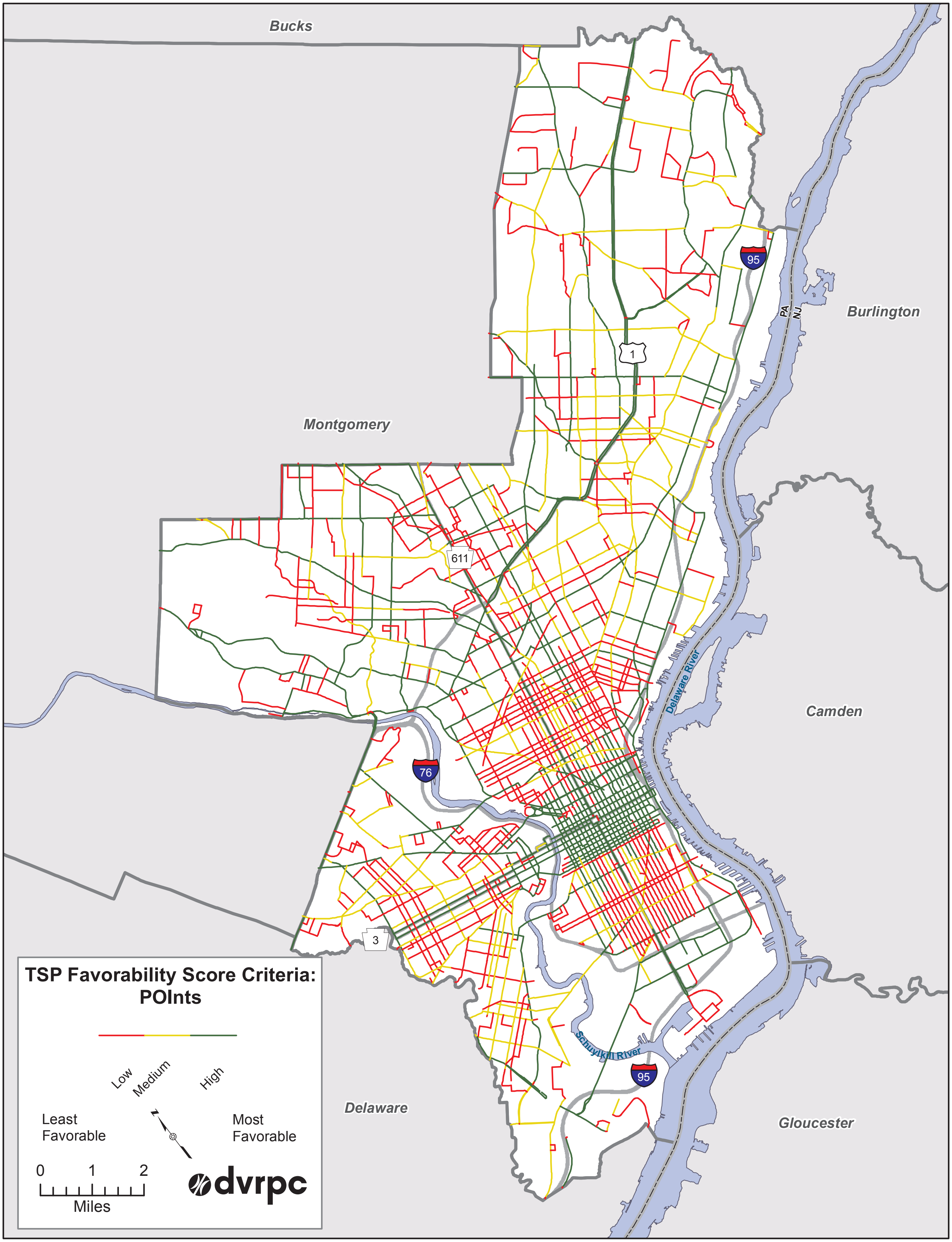

Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
PA
NJ
Delaware River
Schuylkill River
95
1
611
76
3
TSP Favorability Score Criteria: Average Route Length (miles)
0 - 9
10 - 13
14 - 15
16 - 21
22 - 46
Least Favorable
Most Favorable
N
0
1
2
Miles
dvrpc


Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
PA
NJ
Delaware River
Schuylkill River
95
1
611
76
3
95
TSP Favorability Score Criteria: Passenger Activity
0
1 - 62
63 - 228
229 - 742
743 - 6256
Least Favorable
Most Favorable
N
0
1
2
Miles
dvrpc


Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
PA
NJ
Delaware River
Schuylkill River
95
1
611
76
3
TSP Favorability Score Criteria:
Cross-Street Passenger Activity
0 - 43
44 - 508
509 - 1566
1567 - 3853
3854 - 13425
Most
Favorable
Least
Favorable
0
1
2
Miles
dvrpc


Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
PA
NJ
Delaware River
Schuylkill River
95
1
611
76
3
TSP Favorability Score Criteria: Average Passenger Trip Length (miles)
0.0 - 1.8
1.9 - 2.2
2.3 - 3.0
3.1 - 4.7
4.8 - 34.5
Least Favorable
Most Favorable
N
0
1
2
Miles
dvrpc


Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
PA
NJ
Delaware River
Schuylkill River
95
1
611
76
3
TSP Favorability Score Criteria:
ICM Corridor
Not ICM
ICM
Less
Favorable
More
Favorable
0
1
2
Miles
dvrpc


TSP Favorability Score Criteria:
POInts
Low
Medium
High
Least
Favorable
Most
Favorable
0
1
2
Miles
dvrpc
Bucks
Montgomery
Burlington
Camden
Delaware
Gloucester
PA
NJ
Delaware River
Schuylkill River
95
1
611
76
3

The following table contains the full ranked list of all routes in the citywide network.

Rank	Route	Mode	Division	Tsp Score
1	66	Trackless	City Transit	39.80
2	16	Bus	City Transit	36.81
3	56	Bus	City Transit	36.43
4	18	Bus	City Transit	35.03
5	22	Bus	City Transit	34.98
6	80	Bus	City Transit	34.98
7	21	Bus	City Transit	34.86
8	23	Bus	City Transit	34.61
9	44	Bus	City Transit	34.43
10	9	Bus	City Transit	34.23
11	70	Bus	City Transit	34.17
12	47	Bus	City Transit	34.17
13	73	Bus	City Transit	34.05
14	58	Bus	City Transit	33.93
15	26	Bus	City Transit	33.91
16	11	Trolley	City Transit	33.83
17	6	Bus	City Transit	33.32
18	MFO	Bus	City Transit	33.32
19	115	Bus	Suburban	33.27
20	33	Bus	City Transit	33.19
21	42	Bus	City Transit	33.06
22	55	Bus	City Transit	32.98
23	BSO	Bus	City Transit	32.94
24	124	Bus	Suburban	32.92
25	125	Bus	Suburban	32.92
26	14	Bus	City Transit	32.89
27	61	Bus	City Transit	32.88
28	10	Trolley	City Transit	32.85
29	48	Bus	City Transit	32.80
30	97	Bus	Suburban	32.56
31	12	Bus	City Transit	32.40
32	G	Bus	City Transit	32.33
33	1	Bus	City Transit	32.25
34	84	Bus	City Transit	32.15
35	3	Bus	City Transit	32.11
36	R	Bus	City Transit	32.08
37	5	Bus	City Transit	32.06
38	20	Bus	City Transit	31.95
39	13	Trolley	City Transit	31.87
40	34	Trolley	City Transit	31.83

Source: DVRPC 2013

Rank	Route	Mode	Division	Tsp Score
41	62	Bus	City Transit	31.80
42	4	Bus	City Transit	31.71
43	78	Bus	City Transit	31.69
44	31	Bus	City Transit	31.56
45	50	Bus	City Transit	31.54
46	36	Trolley	City Transit	31.48
47	24	Bus	City Transit	31.43
48	17	Bus	City Transit	31.41
49	67	Bus	City Transit	31.30
50	27	Bus	City Transit	31.27
51	K	Bus	City Transit	31.25
52	H	Bus	City Transit	31.24
53	57	Bus	City Transit	31.22
54	108	Bus	Suburban	31.19
55	2	Bus	City Transit	31.14
56	37	Bus	City Transit	31.12
57	L	Bus	City Transit	31.10
58	35	Bus	City Transit	31.08
59	38	Bus	City Transit	30.92
60	XH	Bus	City Transit	30.89
61	64	Bus	City Transit	30.87
62	77	Bus	City Transit	30.85
63	54	Bus	City Transit	30.69
64	65	Bus	City Transit	30.66
65	15	Trolley	City Transit	30.64
66	25	Bus	City Transit	30.62
67	7	Bus	City Transit	30.44
68	60	Bus	City Transit	30.35
69	105	Bus	Suburban	30.25
70	40	Bus	City Transit	30.22
71	8	Bus	City Transit	30.04
72	32	Bus	City Transit	29.87
73	106	Bus	Suburban	29.78
74	46	Bus	City Transit	29.74
75	52	Bus	City Transit	29.46
76	47m	Bus	City Transit	29.43
77	30	Bus	City Transit	29.36
78	68	Bus	City Transit	29.03
79	79	Bus	City Transit	29.00
80	19	Bus	City Transit	28.48
81	LUCY	Bus	City Transit	28.45

Source: DVRPC 2013

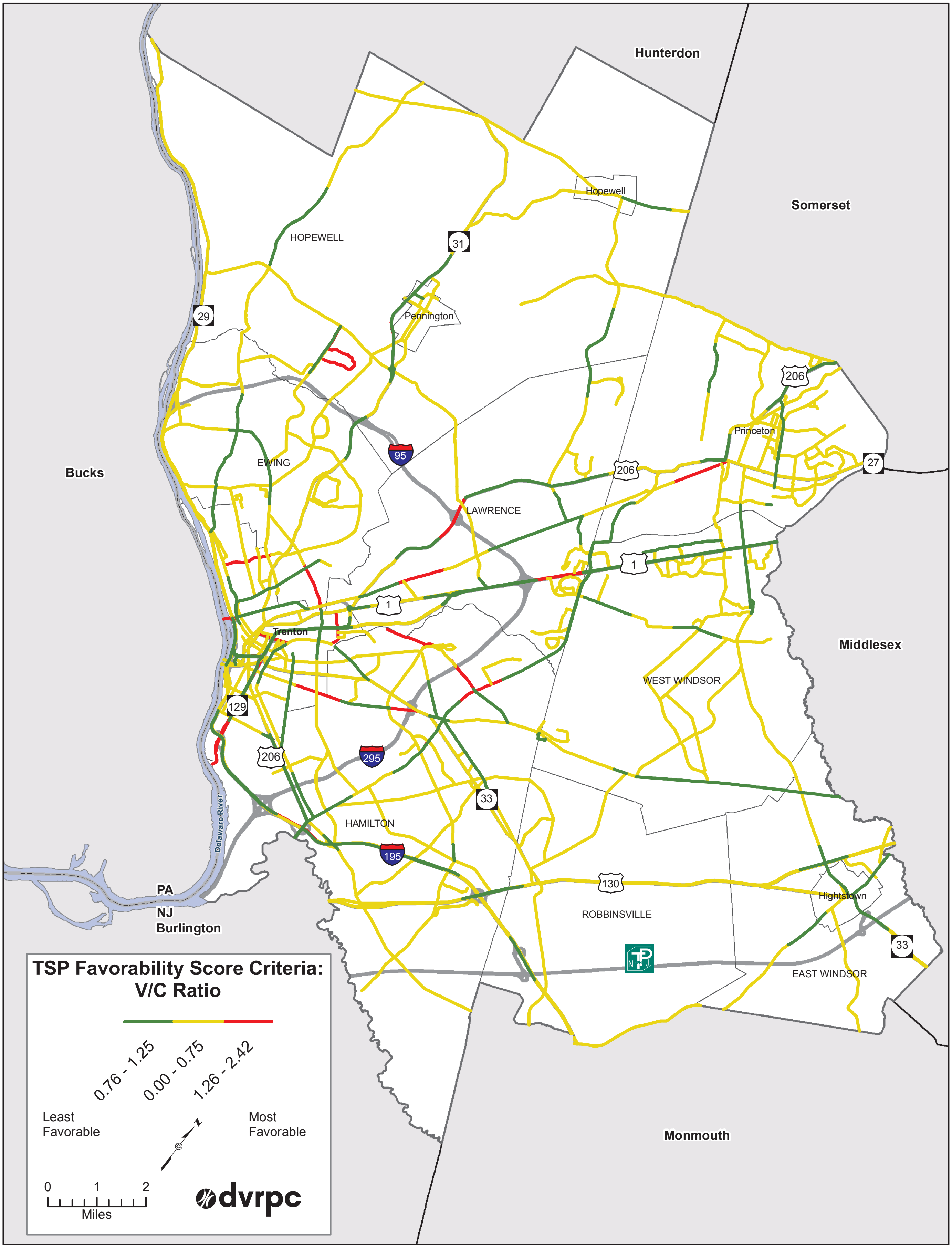
Rank	Route	Mode	Division	Tsp Score
82	53	Bus	City Transit	28.38
83	J	Bus	City Transit	28.34
84	39	Bus	City Transit	28.33
85	29	Bus	City Transit	28.25
86	28	Bus	City Transit	28.07
87	103	Bus	Suburban	27.82
88	88	Bus	City Transit	27.65
89	43	Bus	City Transit	27.65
90	89	Bus	City Transit	27.49
91	116	Bus	Suburban	27.44
92	130	Bus	Suburban	26.90
93	129	Bus	Suburban	26.85
94	94	Bus	Suburban	26.67
95	75	Trackless	City Transit	26.19
96	59	Trackless	City Transit	26.16

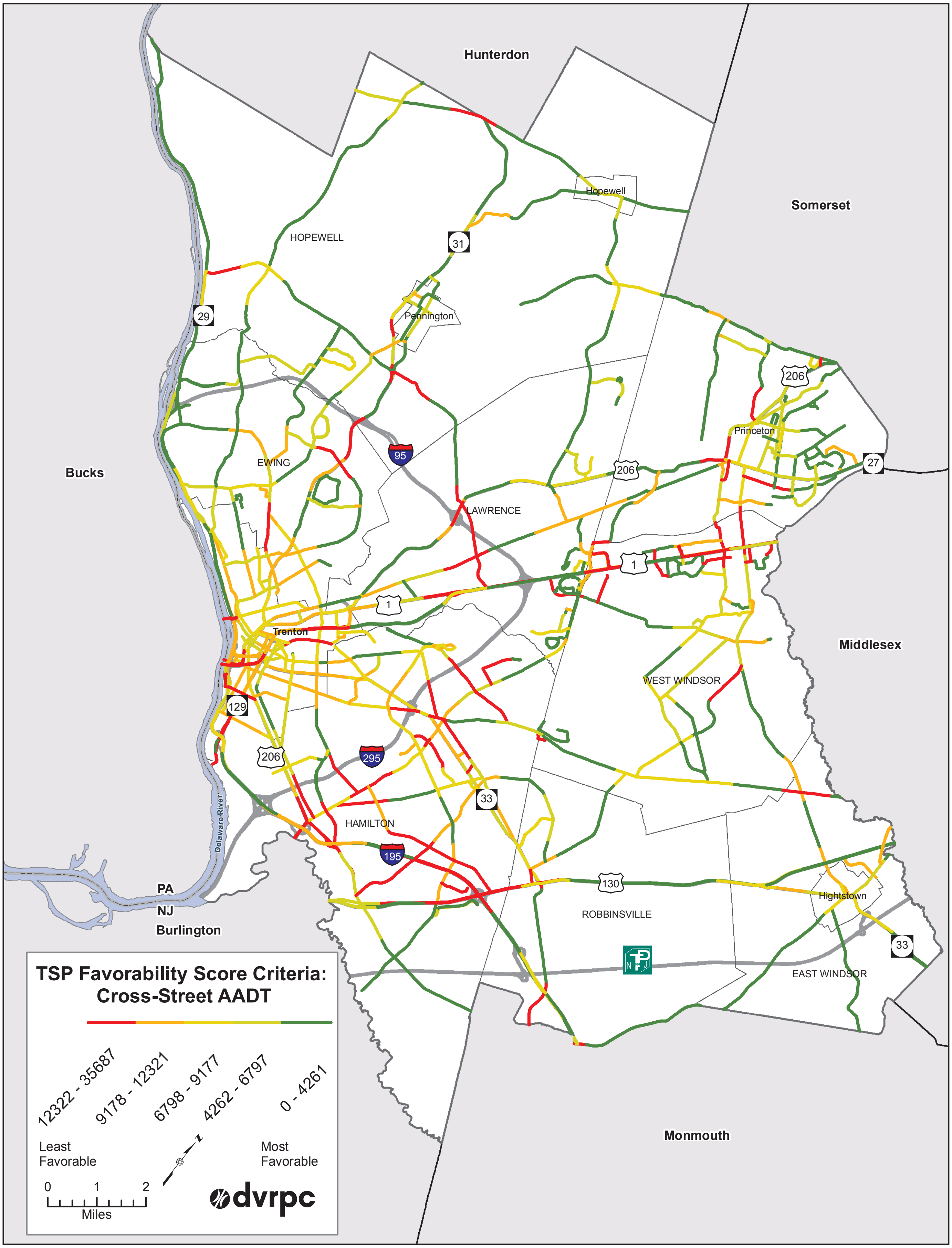
Source: DVRPC 2013

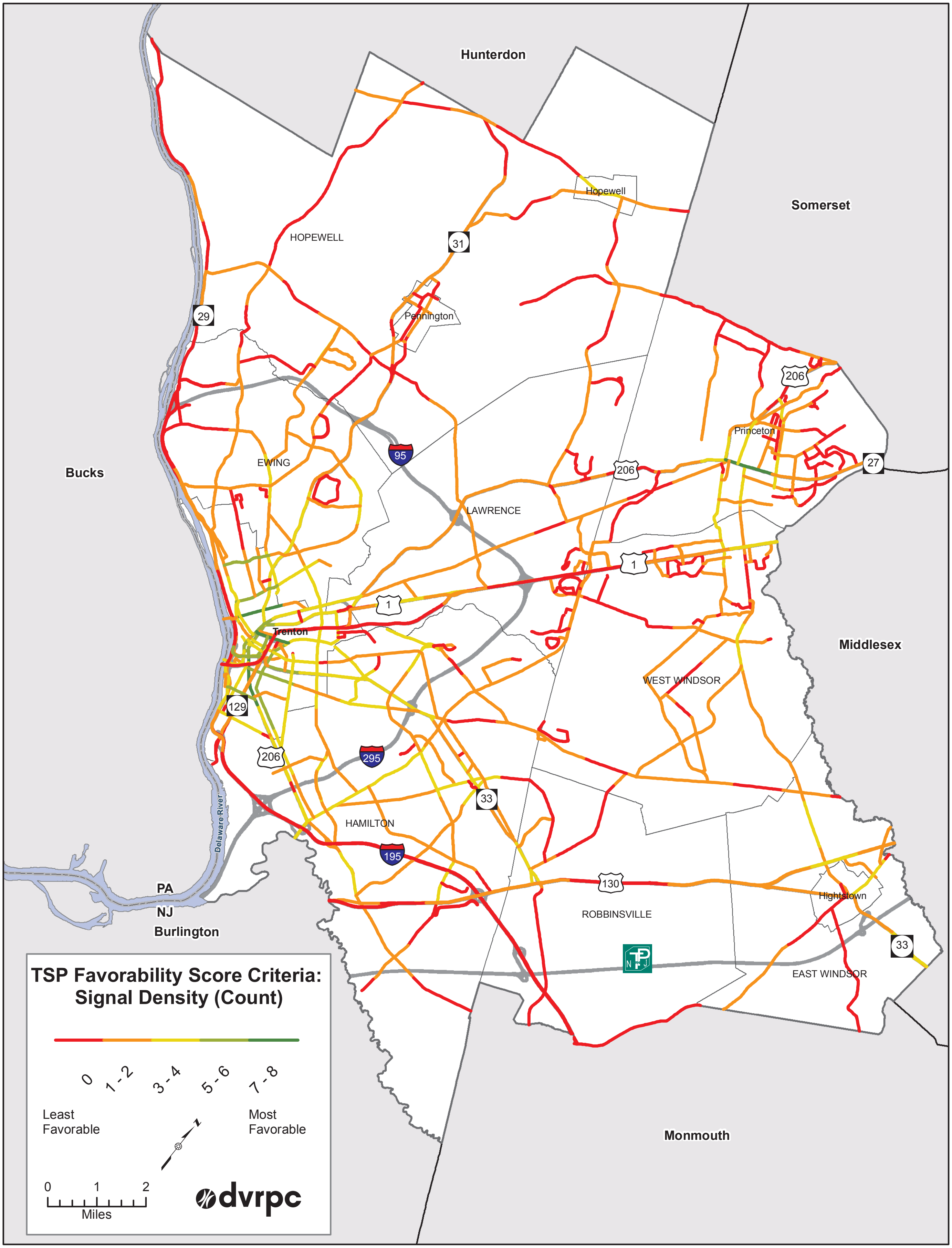
Appendix B

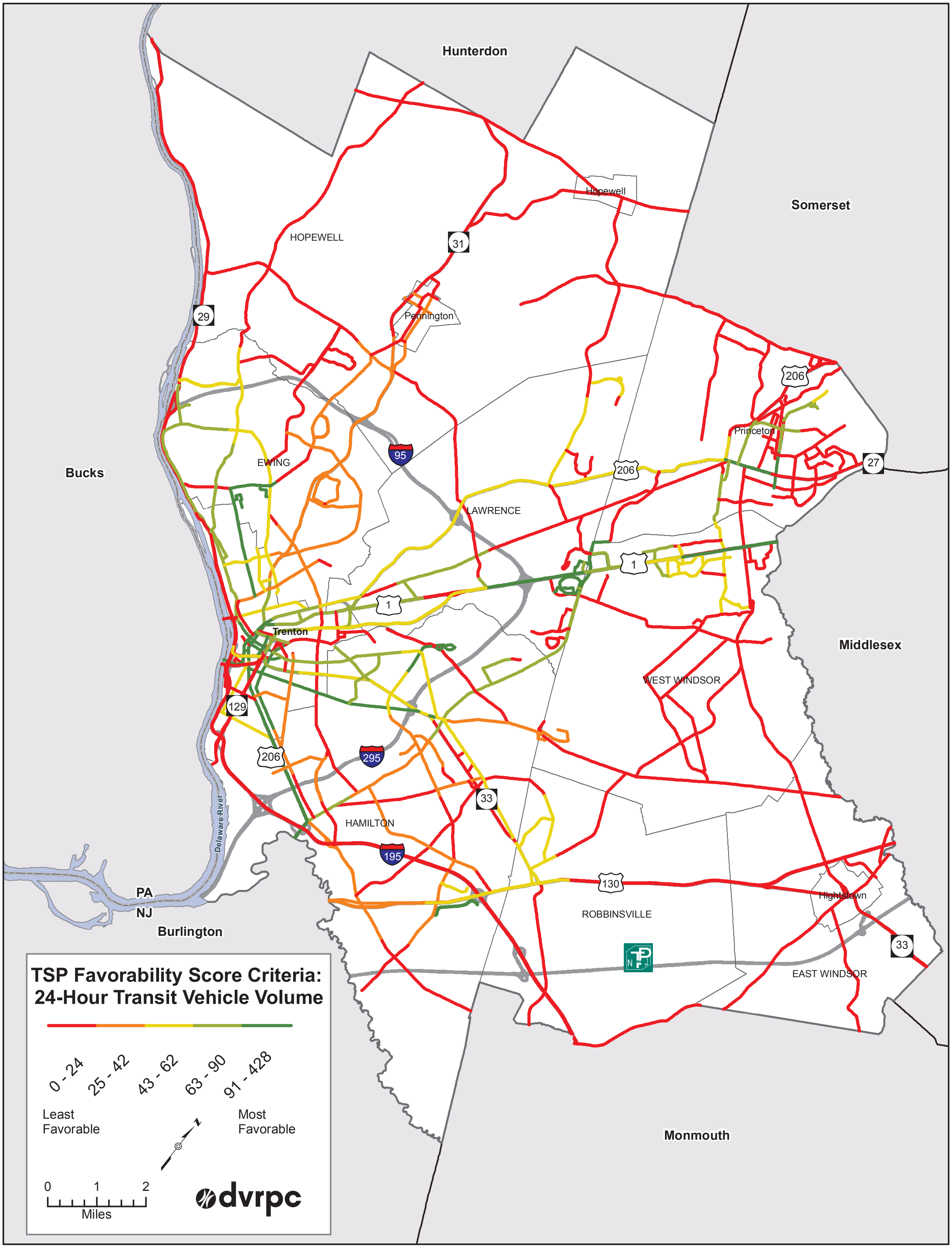
Mercer County Criterion Maps

Appendix B is a succession of maps illustrating how each segment in Mercer County scored by criterion. Please refer to Table 3 on page 20 for more details regarding scoring and weight of each criterion.


Hunterdon
Somerset
Bucks
Middlesex
Monmouth
PA
NJ
Burlington
Delaware River
HOPEWELL
Hopewell
Pennington
EWING
LAWRENCE
Princeton
Trenton
WEST WINDSOR
HAMILTON
ROBBINSVILLE
Hightstown
EAST WINDSOR
29
31
95
206
27
1
129
295
33
195
130
TSP Favorability Score Criteria:
V/C Ratio
0.76 - 1.25
0.00 - 0.75
1.26 - 2.42
Least
Favorable
Most
Favorable
0
1
2
Miles
dvrpc


Hunterdon
Somerset
Bucks
Middlesex
Monmouth
Burlington
PA
NJ
Delaware River
HOPEWELL
Hopewell
Pennington
EWING
LAWRENCE
Princeton
Trenton
WEST WINDSOR
HAMILTON
ROBBINSVILLE
Hightstown
EAST WINDSOR
TSP Favorability Score Criteria:
Cross-Street AADT
12322 - 35687
9178 - 12321
6798 - 9177
4262 - 6797
0 - 4261
Least Favorable
Most Favorable
0 1 2
Miles
dvrpc


Hunterdon
Somerset
Bucks
Middlesex
Monmouth
Burlington
PA
NJ
Delaware River
HOPEWELL
Hopewell
Pennington
EWING
LAWRENCE
Princeton
Trenton
WEST WINDSOR
HAMILTON
ROBBINSVILLE
Hightstown
EAST WINDSOR
29
31
95
206
27
1
129
295
33
195
130
TSP Favorability Score Criteria:
Signal Density (Count)
0
1 - 2
3 - 4
5 - 6
7 - 8
Least Favorable
Most Favorable
0
1
2
Miles
dvrpc



Hunterdon
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Middlesex
Burlington
Monmouth
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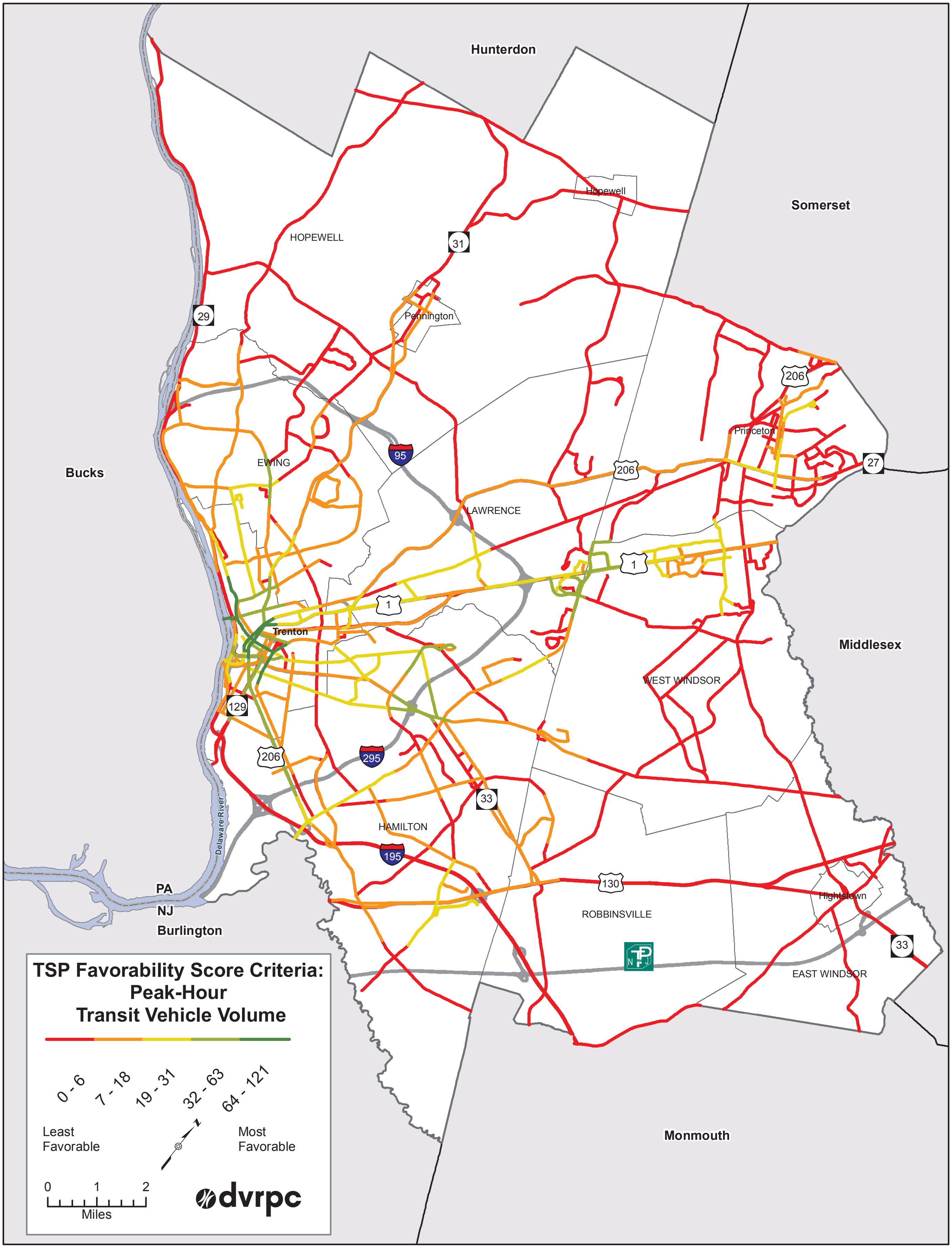
Hopewell
Pennington
EWING
LAWRENCE
Princeton
Trenton
HAMILTON
WEST WINDSOR
ROBBINSVILLE
Hightstown
EAST WINDSOR
Delaware River
PA
NJ
29
31
206
95
27
1
129
295
33
195
130
TSP Favorability Score Criteria:
24-Hour Transit Vehicle Volume
0 - 24
25 - 42
43 - 62
63 - 90
91 - 428
Least Favorable
Most Favorable
0
1
2
Miles
dvrpc


Hunterdon
Somerset
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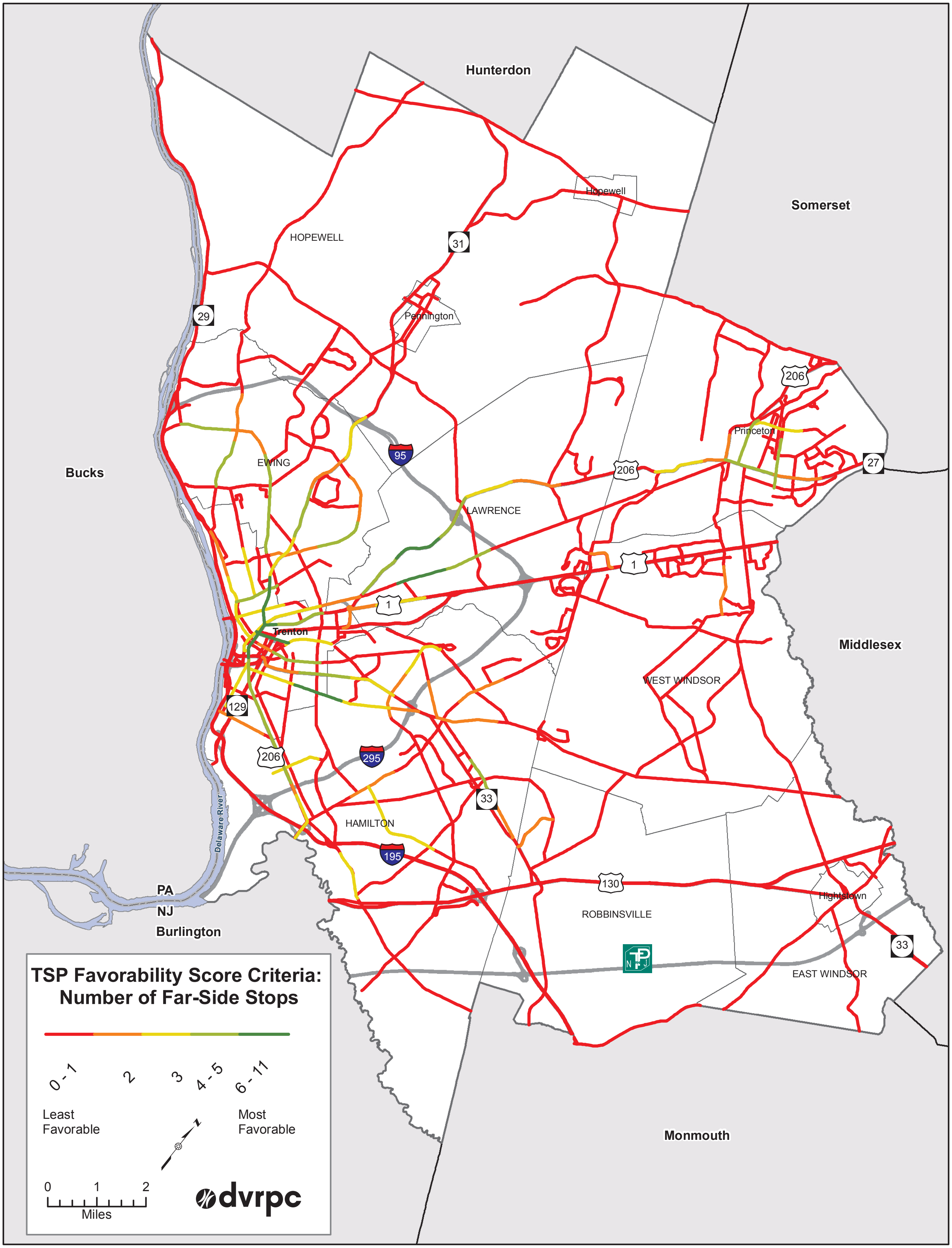
Middlesex
Monmouth
Burlington
PA
NJ
Delaware River
HOPEWELL
Hopewell
Pennington
EWING
LAWRENCE
Princeton
Trenton
WEST WINDSOR
HAMILTON
ROBBINSVILLE
Hightstown
EAST WINDSOR
29
31
95
206
27
1
129
295
33
195
130
TSP Favorability Score Criteria:
Peak-Hour
Transit Vehicle Volume
0 - 6
7 - 18
19 - 31
32 - 63
64 - 121
Least
Favorable
Most
Favorable
0
1
2
Miles
dvrpc



Hunterdon
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Burlington
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Delaware River
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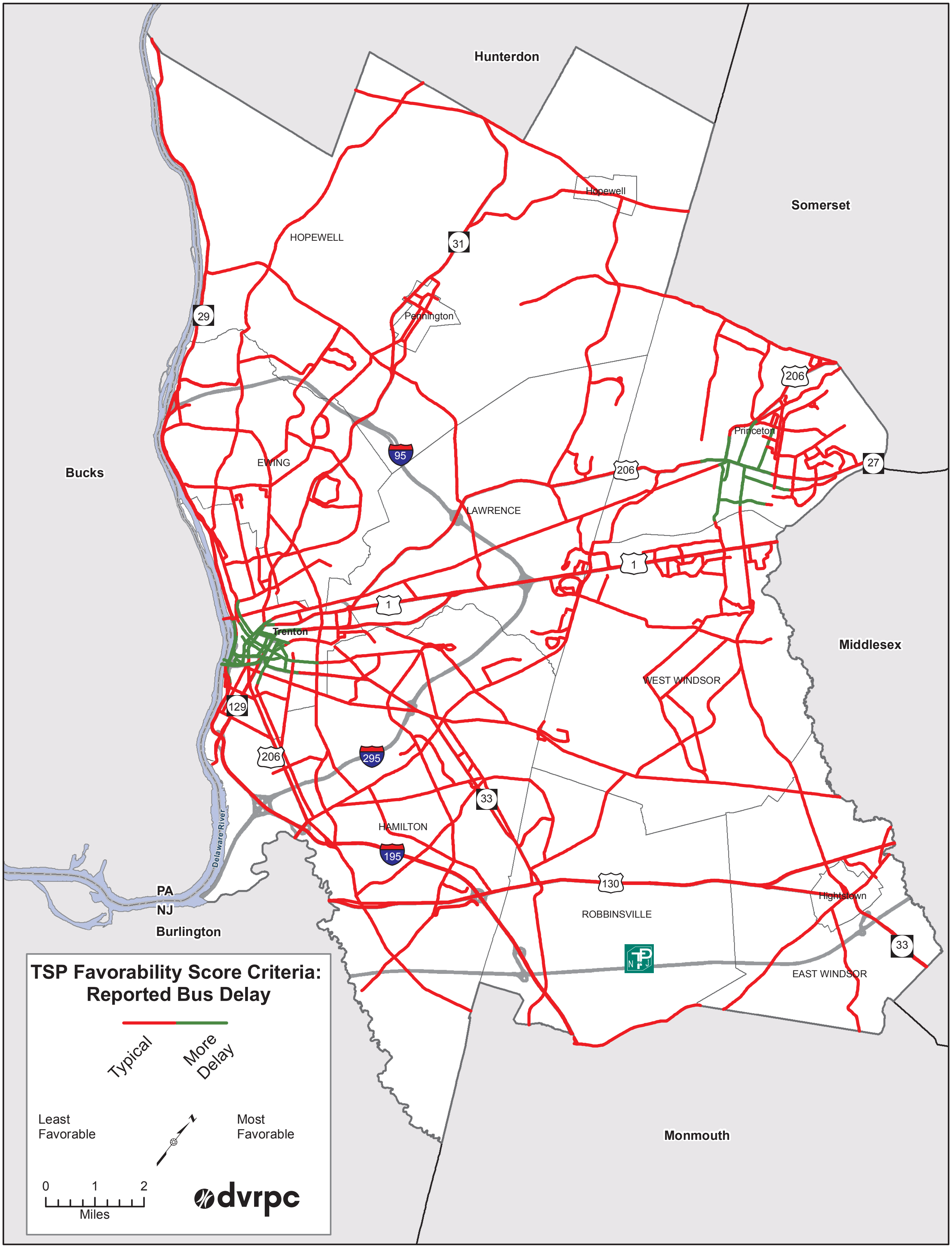
Hopewell
Pennington
EWING
LAWRENCE
Princeton
Trenton
WEST WINDSOR
HAMILTON
ROBBINSVILLE
Hightstown
EAST WINDSOR
29
31
95
206
27
1
129
295
33
195
130
TSP Favorability Score Criteria:
Number of Far-Side Stops
0 - 1
2
3
4 - 5
6 - 11
Least Favorable
Most Favorable
N
0
1
2
Miles
dvrpc


Hunterdon
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Middlesex
Monmouth
Burlington
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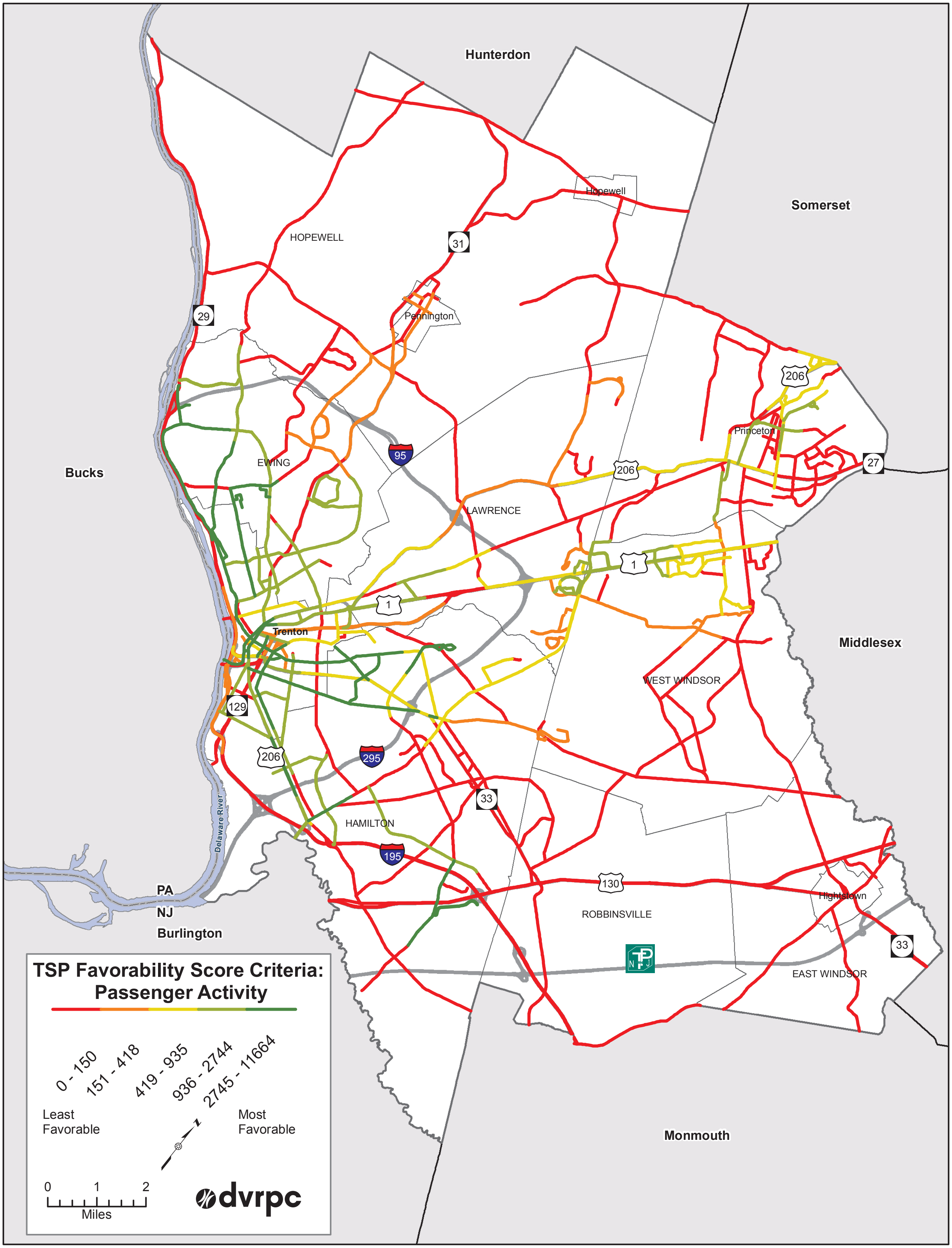
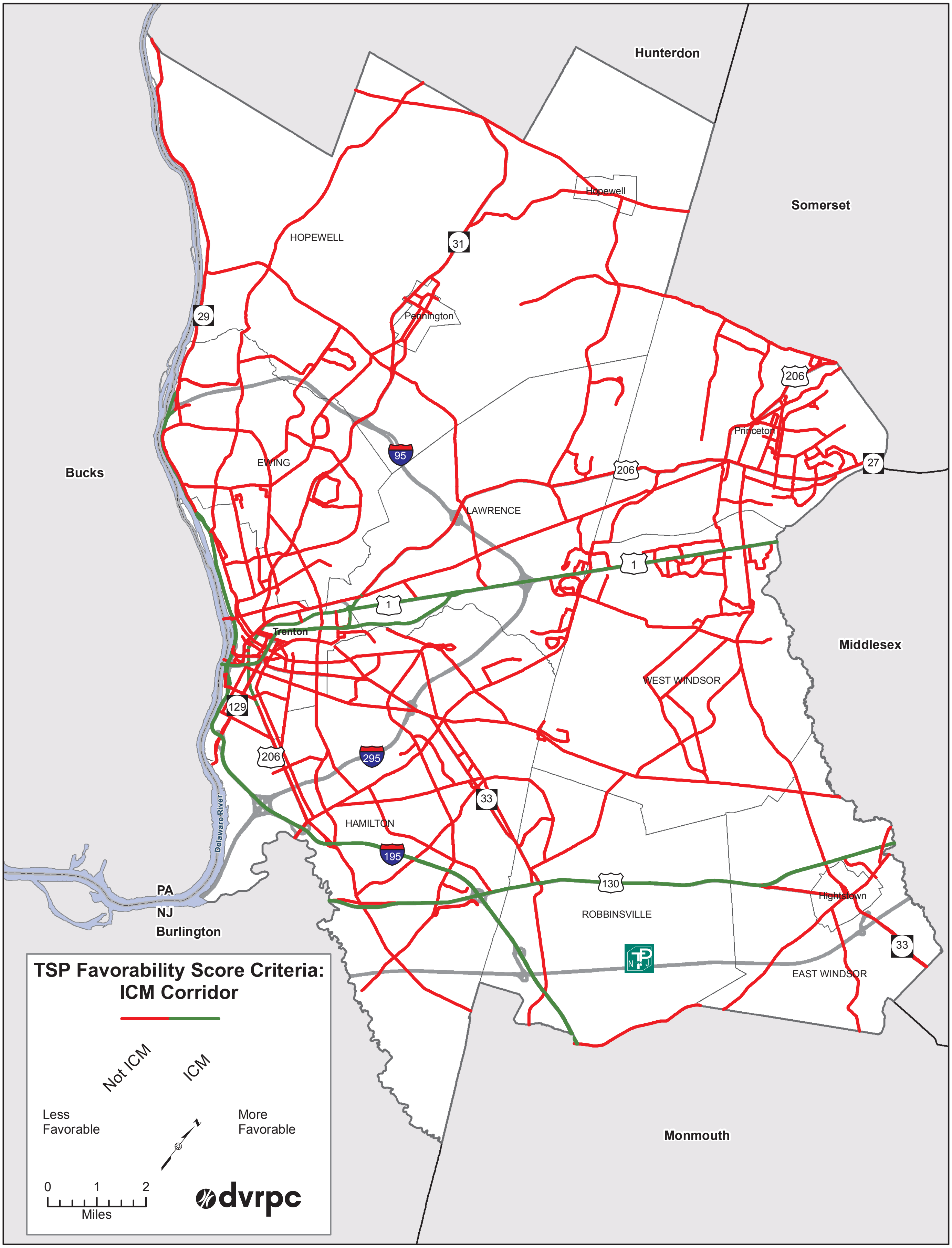
NJ
Delaware River
Hopewell
HOPEWELL
Pennington
EWING
LAWRENCE
Princeton
Trenton
WEST WINDSOR
HAMILTON
ROBBINSVILLE
Hightstown
EAST WINDSOR
29
31
95
206
27
1
129
295
33
195
130
TSP Favorability Score Criteria: Reported Bus Delay
Typical
More Delay
Least Favorable
Most Favorable
0
1
2
Miles
dvrpc


Hunterdon
Somerset
Bucks
Middlesex
Monmouth
Burlington
PA
NJ
Delaware River
HOPEWELL
Hopewell
Pennington
EWING
LAWRENCE
Princeton
Trenton
WEST WINDSOR
HAMILTON
ROBBINSVILLE
Hightstown
EAST WINDSOR
31
29
95
206
27
1
129
295
33
195
130
TSP Favorability Score Criteria:
Passenger Activity
0 - 150
151 - 418
419 - 935
936 - 2744
2745 - 11664
Least
Favorable
Most
Favorable
0
1
2
Miles
dvrpc



Hunterdon
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Middlesex
Monmouth
Burlington
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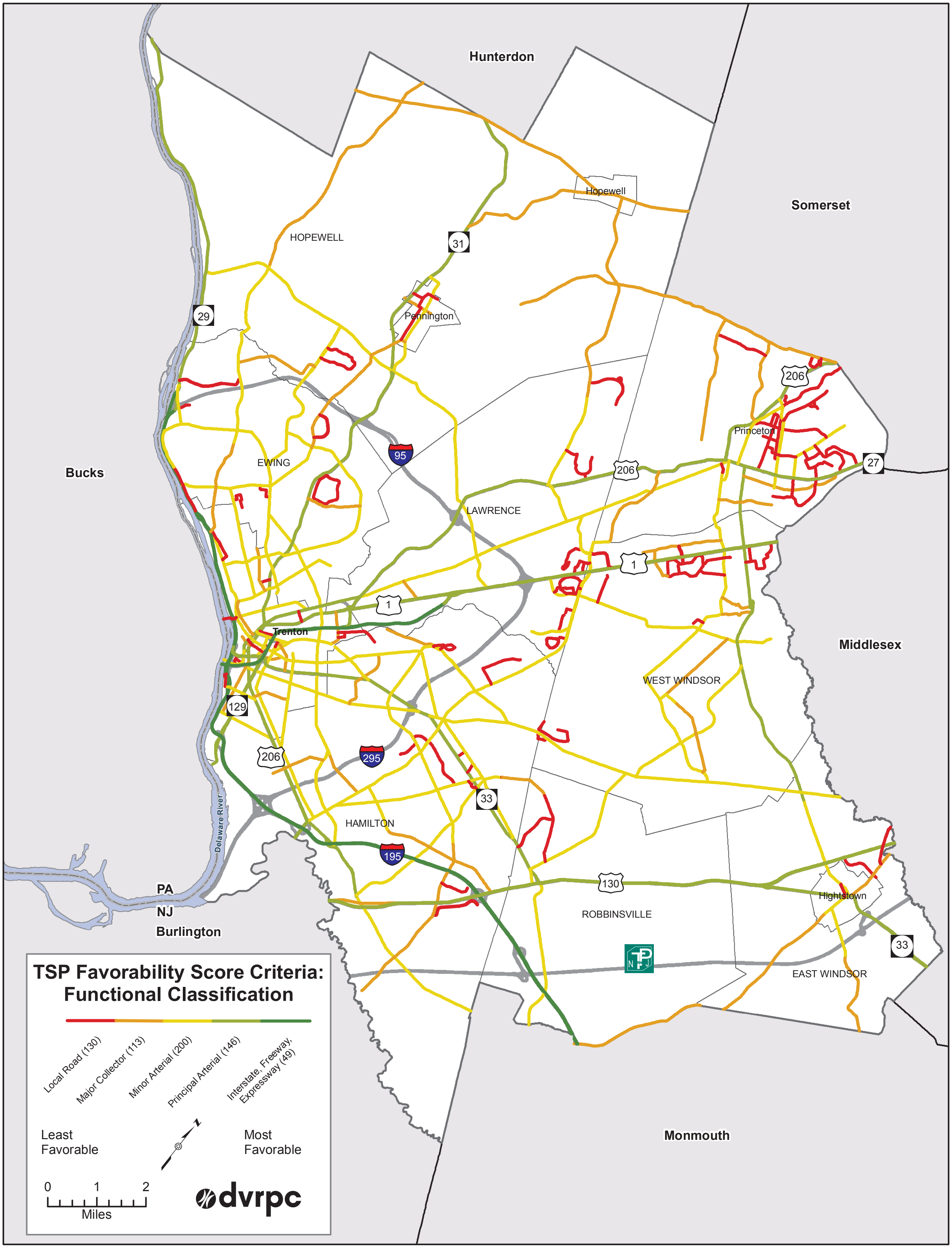
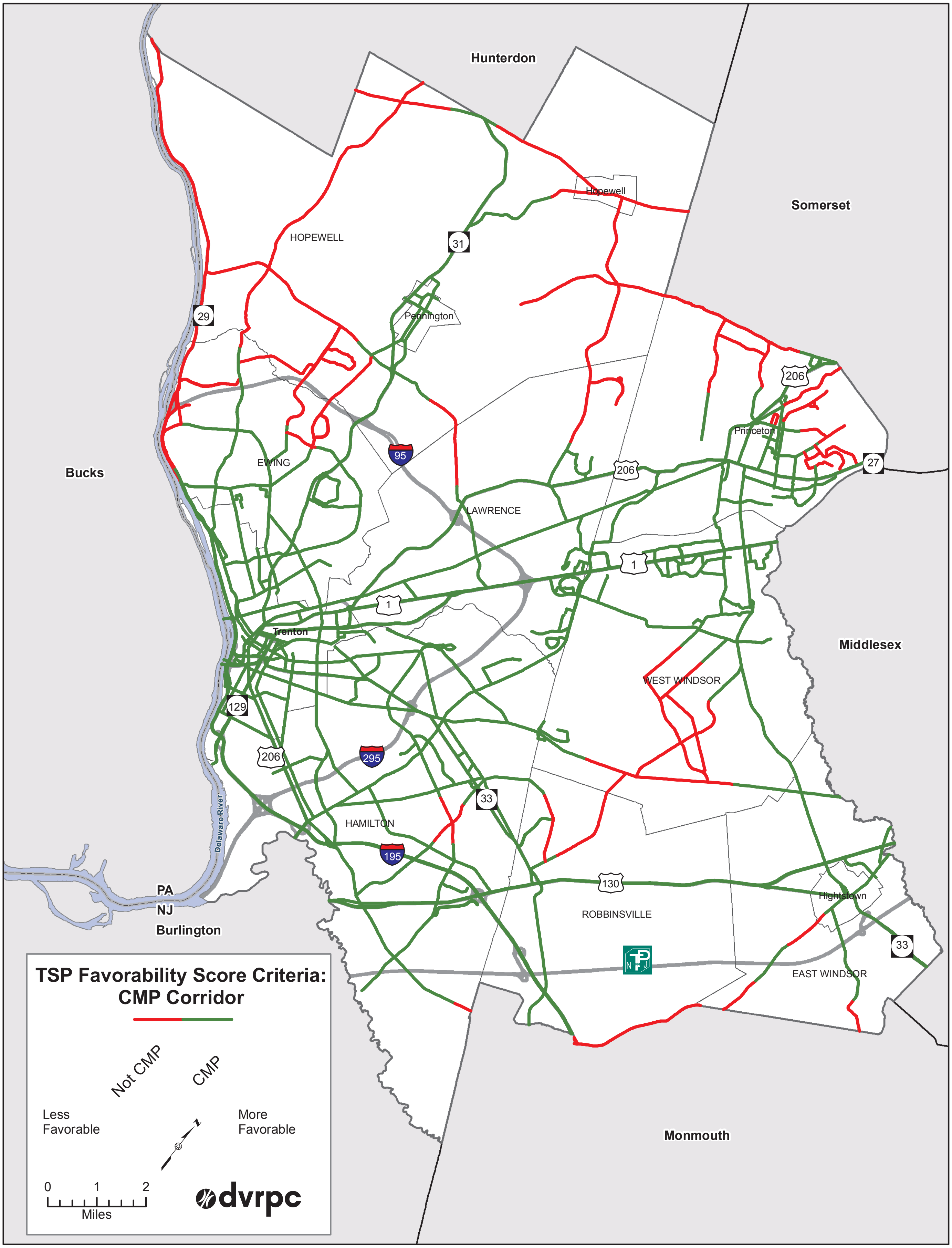
NJ
Hopewell
HOPEWELL
Pennington
EWING
LAWRENCE
Princeton
Trenton
WEST WINDSOR
HAMILTON
ROBBINSVILLE
Hightstown
EAST WINDSOR
Delaware River
31
29
206
95
27
1
129
295
33
195
130
TSP Favorability Score Criteria: ICM Corridor
Not ICM
ICM
Less Favorable
More Favorable
0
1
2
Miles
dvrpc


TSP Favorability Score Criteria: Functional Classification
Local Road (130)
Major Collector (113)
Minor Arterial (200)
Principal Arterial (146)
Interstate, Freeway, Expressway (49)
Least Favorable
Most Favorable
0
1
2
Miles
dvrpc
Hunterdon
Somerset
Middlesex
Bucks
Monmouth
Burlington
PA
NJ
Delaware River
HOPEWELL
Hopewell
Pennington
EWING
LAWRENCE
Princeton
Trenton
WEST WINDSOR
HAMILTON
ROBBINSVILLE
Hightstown
EAST WINDSOR
31
29
95
206
27
1
129
295
33
195
130


TSP Favorability Score Criteria: CMP Corridor
Not CMP
CMP
Less Favorable
More Favorable
0
1
2
Miles
dvrpc
Hunterdon
Somerset
Bucks
Middlesex
Monmouth
Burlington
PA
NJ
Delaware River
HOPEWELL
Hopewell
Pennington
EWING
LAWRENCE
Princeton
Trenton
WEST WINDSOR
HAMILTON
ROBBINSVILLE
Hightstown
EAST WINDSOR
31
29
206
95
27
1
129
295
33
195
130

Transit Signal Priority Favorability Score: Development and Application in Philadelphia and Mercer County

Publication Number: 13033

Date Published: April 2014

Geographic Area Covered: Philadelphia, Pennsylvania and Mercer County, New Jersey

Key Words: Philadelphia, Mercer County, Transit Signal Priority, SEPTA, New Jersey Transit, Bus, Public Transportation

Abstract: This study examines traffic signal and surface transit routes in Philadelphia and Mercer counties and develops a method of scoring corridors on their likelihood for successful and cost-effective TSP and related signals investments. To develop a TSP prioritization framework, the study team has built upon prior data gathering, analysis, and mapping work. The screening tool that was developed here identifies the corridors where TSP is likely to be the most effective and have the greatest operational benefits for transit and all road users.

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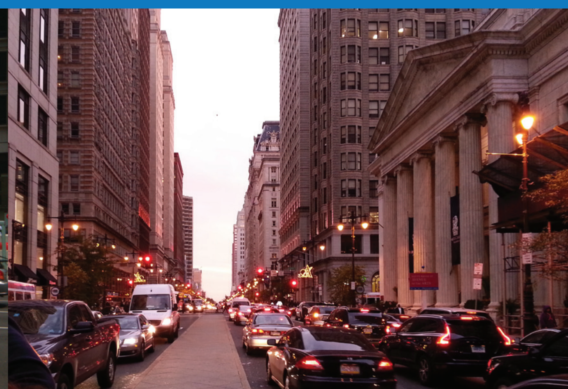


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