APPENDIX C

High Risk Network Development

UNION COUNTY SAFE STREETS FOR ALL ACTION PLAN

Background

Union County, New Jersey, comprises 21 municipalities and serves approximately 580,000 residents. While the county's road network includes major arterials such as US Route 1&9, Garden State Parkway, I-78, I-95, I-278, local roads make up a majority of the county's roadway mileage. The county roadway system carries heavy traffic volumes comprised of local trips, daily commuters, and freight movement in a built environment that includes both suburban and urban land uses. This mix of roadways throughout most of the county creates a complex transportation environment shared by drivers, bicyclists, pedestrians, and transit users.

Funded by a grant provided by the United States Department of Transportation's (USDOT's) Safe Streets and Roads for All (SS4A) grant program, the County is developing a Safety Action Plan aimed at evaluating current conditions and identifying strategies to reduce the number of fatalities and serious injuries on its roadways. The City of Elizabeth, as a subrecipient on the grant, is partnering with Union County on this effort. The plan's goals are to evaluate recent crash data and identify underlying trends, high-injury corridors, and key risk features that contribute to traffic crashes in Union County and in the City of Elizabeth. By assessing these patterns, the County aims to understand where and why crashes are occurring and to evaluate the potential risk levels across its roadway network. This data-driven approach will inform the development of a prioritized list of locations and recommended countermeasures, forming the basis for an implementation plan that proposes targeted safety interventions.

In consideration of these challenges, and to support the County's efforts to minimize traffic-related deaths and injuries, the project team developed a **"High Risk Network"** which identifies roadway segments with elevated potential crash risk based on existing roadway characteristics including posted speed limit, number of lanes, traffic volumes, and proximity to pedestrian and bicycle activity generators, among others. This memorandum outlines the process and findings from the development of the high-risk network. The goal of this analysis is to support Union County's efforts to help prioritize locations for future safety interventions.

Methodology

This report builds on the detailed crash trends analysis conducted previously, which examined crash patterns and severity across Union County and the City of Elizabeth. That foundational work addressed crash data preparation and general trends; therefore, this memorandum focuses on the High Risk Network (HRN) development. HRN development is a process that identifies contributing roadway characteristics and/or operational features that could potentially contribute to crash overrepresentations, with a specific focus on Killed and Serious Injury (KSI) crashes to align with the safe systems approach.

High-Risk Network Assembly

The foundation of the HRN analysis is a detailed roadway network assembled from NJDOT's Straight Line Diagram (SLD) data browser. This dataset provides comprehensive roadway features critical for understanding risk features. Key features include route subtype, functional class, roadway directionality (one-way or two-way), shoulder width, posted speed limit, lane count, pavement width, truck access designation, and traffic volumes measured as Annual Average Daily Traffic (AADT). Additional data, including free flow speed and truck AADT, were obtained from Replica, a travel mobility analytical platform.

Beyond these core roadway features, additional contextual data points were spatially linked to the network to support the analysis of Vulnerable Road User (VRU) risk features, i.e. those associated with bicycle and pedestrian crashes. These include intersections and the proximity of libraries, schools, bus stops, and train stations, measured within set distances from each segment (e.g., schools and libraries within ¼ mile, bus stops within 50 feet, train stations within ½ mile). Intersections were further characterized by their count, total intersection approaches, and whether they are signalized or unsignalized.

This assembled and segmented network, enriched with both roadway and contextual features, was spatially joined with the crash data to form the foundation for statistical evaluation of contributing risk factors.

Risk Features Evaluation and Scoring

Subsequent analysis involved isolating individual features and comparing their associated KSI crash rates against the baseline crash rate, calculated as total KSI crashes per mile of roadway. Features showing rates higher than the baseline were identified as increasing risk, while those with lower rates were considered less impactful or not statistically representative.

Based on this comparative analysis and accounting for potential overlap among correlated variables (e.g., posted speed vs. free flow speed) and statistical significance, a subset of key features was selected for scoring. These include roadway characteristics such as posted speed limit, route subtype, directionality, intersection presence and signalization, AADT, truck route designation, and proximity to VRU generators such as schools, transit stops, and libraries.

Each roadway segment was then assigned points reflecting its inherent riskiness. These points were summed across features to produce an overall risk score, which forms the basis of the HRN. This methodology allows for a nuanced, multi-feature assessment of crash risk at a detailed spatial level, supporting targeted safety planning in Union County.

Evaluation Criteria and Scoring

This section assesses the impact of various roadway and contextual characteristics on KSI crashes. To minimize potential double counting effects, interrelated features such as posted speed limit and free-flow speed were carefully analyzed. The team also reviewed additional data sets, including proximity to libraries, school enrollments / types, roadway functional class, and truck traffic volumes. These data sets were subsequently removed due to statistical irrelevance to ensure only the most informative and statistically significant variables were retained for scoring. Based on statistical distinctiveness and explanatory strength, the final set of risk features included four organizing categories:

- **Roadway Characteristics**: posted speed limit, route subtype, number of lanes, directionality, intersection type, and traffic control types
- **Traffic Volumes:** Average Annual Daily Traffic (AADT)
- **Heavy Truck Traffic**: truck access route designation
- **Vulnerable Road User (VRU) Generators**: proximity to pedestrian and bicycle activity generators such as train stations, bus stops, and schools

Roadway segments were then assigned points for each feature, reflecting their relative KSI crash risk. While the assigned points generally correspond to the crash factor (e.g., a crash factor of 2.2 typically yields a point of 2), this relationship was not strictly linear. In some cases, points were adjusted to better align with the overall scoring framework, ensuring balanced weighting across features.

Table 1 shows an example of how points were assigned for the "posted speed" feature. Speeds were grouped in 10 mph unit bins, with those above 45 aggregated due to limited data and similar crash rates. Points correspond to crash risk compared to baseline rates, factoring in engineering judgment to highlight high-risk scenarios. The crash rates and factors in Table 1 show that higher posted speed limits are linked to greater KSI crash likelihood: roads under 30 mph (crash factor <1) received 0 points, speeds 35-40 mph (crash rate twice the baseline) received 2 points, and speeds of 45 mph or more (crash factor >2) were assigned 4 points to account for their higher risk.

Table 1: Crash Rate and Points by Posted Speed

Posted Speed	Crash Rate (KSI/Mileage)	Crash Factor	Points
≤20	0.8	**0.6 ×**	**0**
25-30	1.0	**0.8 ×**	**0**
35-40	2.7	**2.0 ×**	**2**
≥45	3.3	**2.5 ×**	**4**

A similar methodology was employed to combine and score other roadway and operational features. Table 2 shows the maximum points possible for each feature. Each roadway segment can score up to 42 points, which is solely a benchmark for comparison. A higher score indicates that the geometric and operational features of a roadway segment are more strongly linked to increased risk.

Table 2: Point Summary

Maximum Points by Risk Features (Higher = Riskier)				
Risk Category	**Risk Feature**	**Percentage**	**Points**	**Total Points**
Roadway Characteristics	Posted Speed	10%	4	**24 (57%)**
	Route Subtype	14%	6	
	Number of Lanes	14%	6	
	Intersection	19%	8	
Traffic Volumes	AADT	14%	6	**6 (14%)**
Heavy Truck Traffic	Truck Access Route	10%	4	**4 (10%)**
VRU Generators	Train	5%	2	**8 (19%)**
	Bus	10%	4	
	School	5%	2	
Total				**42**

The total HRN score for each segment was calculated by summing individual scores across all selected risk features. This composite score provides a comparative measure of segment-level risk, enabling targeted prioritization for safety interventions.

Risk Features and Crash Rates

ROADWAY CHARACTERISTICS

Table 3 through Table 11 show the number of points assigned to each feature.

Posted Speed Limit: The breakdown example illustrated in the previous section demonstrated that roadways with higher posted speed limits were assigned higher points due to the increased level of risk.

Table 3: Points by Posted Speed

Posted Speed	Points
≤20	**0**
25-30	**0**
35-40	**2**
≥45	**4**

Route Subtype: Analysis indicates that higher KSI crash rates are linked to major roadway classes. US routes, which exhibit an overrepresentation of KSI crashes, were thus assigned the maximum possible points (6). In contrast, local routes, due to their lower KSI crash rates, did not receive any points.

Table 4: Points by Route Subtype

Route Subtype	Points
Local Route	**0**
Other County Route	**2**
500 Series Route	**2**
State Route	**4**
US Route	**6**

Number of Lanes: This feature is categorized into one-way streets (including divided roadways) and two-way streets. Analysis indicates that directionality significantly influences crash patterns. One-way streets with three or more lanes exhibit the highest rate of KSI crashes and therefore received the most points. In contrast, one-lane one-way streets and one-lane two-way streets (such as alleyways) demonstrate a lower likelihood of KSI crashes and were assigned no points.

Table 5: Points by Number of Lanes

	Number of Lanes	Points
One-way Street/Divided Roadway	1	**0**
	2	**2**
	≥3	**6**
Two-way Street	1	**0**
	2	**1**
	3	**2**
	≥4	**4**

Intersections: Unlike other features that depend directly on calculated crash rate ratios, roadways are evaluated using a tiered scoring system to more accurately represent the combined risks and design considerations. Road segments containing any intersection received a base score of 2 points, since intersections exhibit a KSI crash rate twice that of the baseline. For signalized intersections, an additional 6 points were assigned for a total of 8, reflecting their approximately eightfold increased likelihood of KSI crashes compared to baseline. Unsignalized intersections were allocated 2 additional points, resulting in a total of 4 points. Intersections not classified as signalized or unsignalized by NJDOT (such as median U-turns or jughandles) were assigned only the base 2 points. This methodology ensures that both the existence and type of intersection control are systematically incorporated into the final risk assessment.

Table 6: Points by Intersection Types

Intersection	Points
No Intersection	**0**
Intersection	**2**
Signalized Intersections*	**+6**
Non-Signalized Intersections*	**+2**

** These points are in addition to base points*

TRAFFIC VOLUME

This category investigates how AADT levels relate to KSI crash rates. Road segments were classified by different AADT ranges, which also reflect, to some extent, the functional classification of each road. Generally, roads with higher traffic volumes, such as major arterials, tend to have more lanes, greater capacity, and additional operational complexities.

Roadway segments with low traffic volumes (less than 5,000 AADT) had crash rates at or below the baseline and were not assigned any points. In contrast, segments with moderate to high volumes showed increasingly elevated crash rates and were assigned the maximum of 6 points.

Table 7: Points by AADT

AADT	Points
<2,000	**0**
2,000-5,000	**0**
5,000-10,000	**2**
10,000-15,000	**4**
15,000-20,000	**6**
>20,000	**6**

HEAVY TRUCK TRAFFIC

Table 8 presents the riskiness and points allocated to designated truck routes. This category accounts for the correlation between crashes and the interaction of heavy truck traffic with other modes of transportation.

Segments not designated as truck access routes had crash rates consistent with the baseline and were not assigned any points. In contrast, segments that are designated truck access routes showed a crash rate over four times higher than the baseline and were assigned 4 points to reflect the elevated risk.

Table 8: Points by Truck Access Route

Truck Access Route	Points
Not A Truck Access Route	**0**
Truck Access Route	**4**

VULNERABLE ROAD USER (VRU) GENERATORS

This category captures the influence of pedestrian and bicycle activity generators on KSI crash rates. For each of the different generators included in this analysis, different buffer distances were evaluated, as described next.

Train Stations: Segments within 0.5 miles of a train station had a KSI crash rate twice the baseline and received 2 points.

Table 9: Points by Nearby Train Stations

Nearby Train Stations	Points
No train station within 0.5 mile	**0**
Train station(s) within 0.5 mile	**2**

Bus Stops: Segments with a bus stop within 50 feet had a crash rate 3.2 times the baseline. These segments were assigned 4 points, reflecting the strong association between bus stop activity and elevated KSI crash risk.

Table 10: Points by Nearby Bus Stops

Nearby Bus Stops	Points
No bus stop within 50 feet	**0**
Bus stop(s) within 50 feet	**4**

Schools: Segments within 0.25 miles of a school experienced a crash rate twice the baseline. These segments were assigned 2 points.

Table 11: Points by Nearby Schools

Nearby Schools	Points
No school within 0.25 mile	**0**
School(s) within 0.25 mile	**2**

High Risk Network

After assigning points based on each of the selected roadway and contextual risk features, a composite HRN score was calculated for each segment. To better understand the spatial distribution of crash risk, each segment's composite score was categorized into four risk levels using percentile groupings:

- **Very High Risk:** 81st to 100th percentile
- **High Risk:** 51st to 80th percentile
- **Medium Risk:** 21st to 50th percentile
- **Low Risk:** 0 to 20th percentile

Separate maps were created for each of the four aspects of the scoring framework to identify geographic patterns and potential hotspots for targeted intervention. A detailed visualization of the HRN within the City of Elizabeth was also developed as a subset of the overall county HRN. This localized view highlights segment-level variations in risk, helping to identify specific areas that may warrant prioritized safety improvements.

ROADWAY CHARACTERISTICS

Table 12 shows that, among the three roadway classifications, the majority of state route mileage falls into the High Risk category (53%), indicating elevated crash risk on these major corridors. County routes are most commonly categorized as Medium Risk (68%), while local routes overwhelmingly fall into the Low Risk category (91%).

Table 12: Roadway Characteristics Risk Level Summary

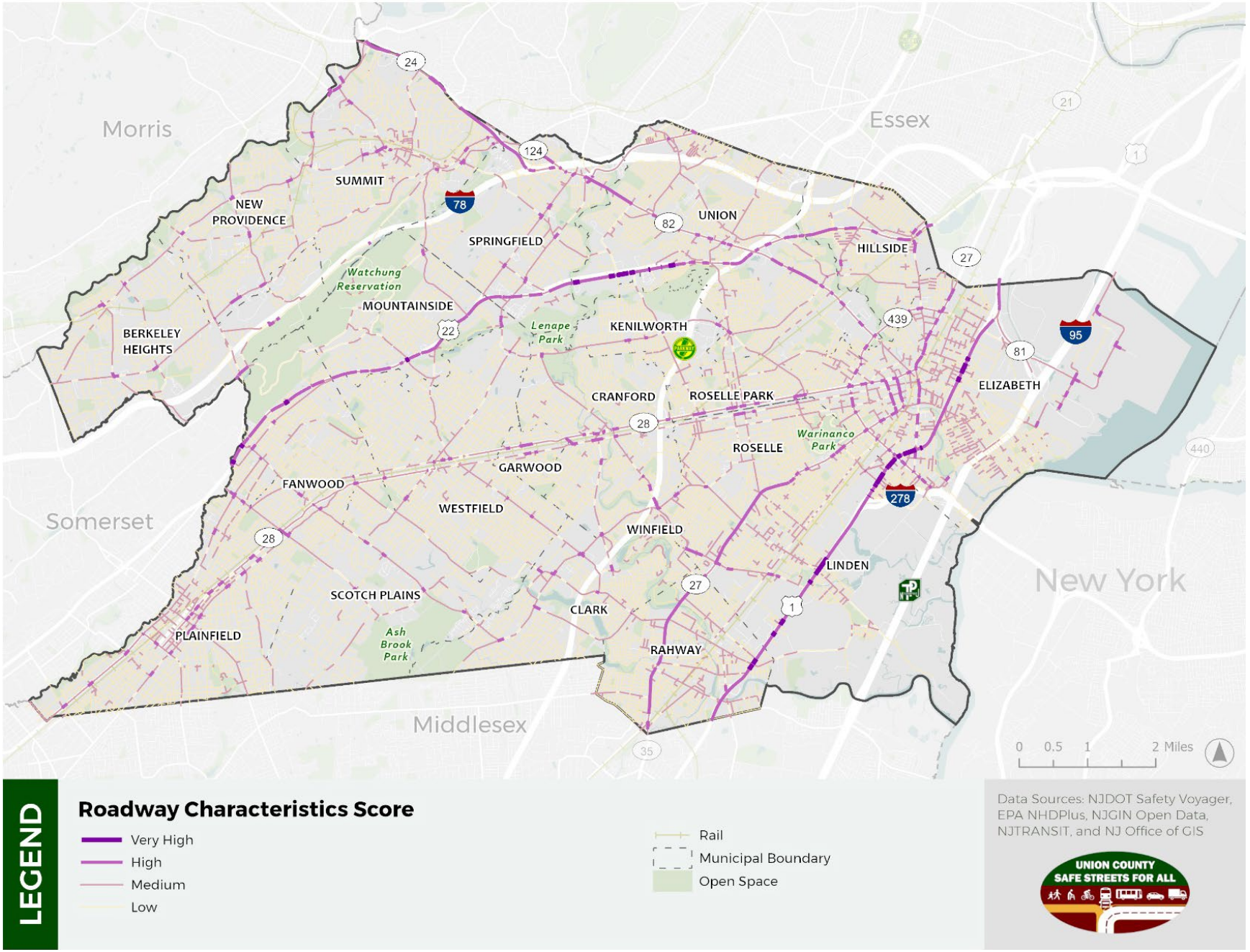
Centerline Mileage by Route Subtype			
Risk Level	**State Route**	**County Route**	**Local Route**
Low (0-5)	1.0 (2%)	48.4 (25%)	**1069.4 (91%)**
Medium (6-12)	25.6 (41%)	**129.8 (68%)**	108 (9%)
High (13-19)	**32.9 (53%)**	12.0 (6%)	1.2 (0%)
Very High (20-24)	2.7 (4%)	0 (0%)	0 (0%)

Max Points Possible: 24

As shown in Figure 1 Roadway Characteristics Score by Risk Level, Very High Risk segments are concentrated along state routes, particularly US 1&9 and US 22, which serve as major regional arterials. High Risk segments are also prevalent on NJ 24, NJ 27, and NJ 28, with several additional segments clustered around NJ 82.

In terms of municipal distribution, there is a clear concentration of High and Very High Risk segments in the urbanized areas of the City of Elizabeth, Roselle Park, Rahway, Linden, Summit, and Plainfield. However, most other municipalities in Union County also contain some level of elevated risk segments.

Figure 1: Roadway Characteristics Score by Risk Level



TRAFFIC VOLUME

When evaluating risk based on Average Annual Daily Traffic (AADT), local routes overwhelmingly fell into the Low Risk category, with 90% of segments scoring at the lowest level, as shown in Table 13. In contrast, Very High Risk segments were predominantly found on state routes, which made up 79% of all segments in that category, followed by smaller shares on county (8%) and local roads (1%).

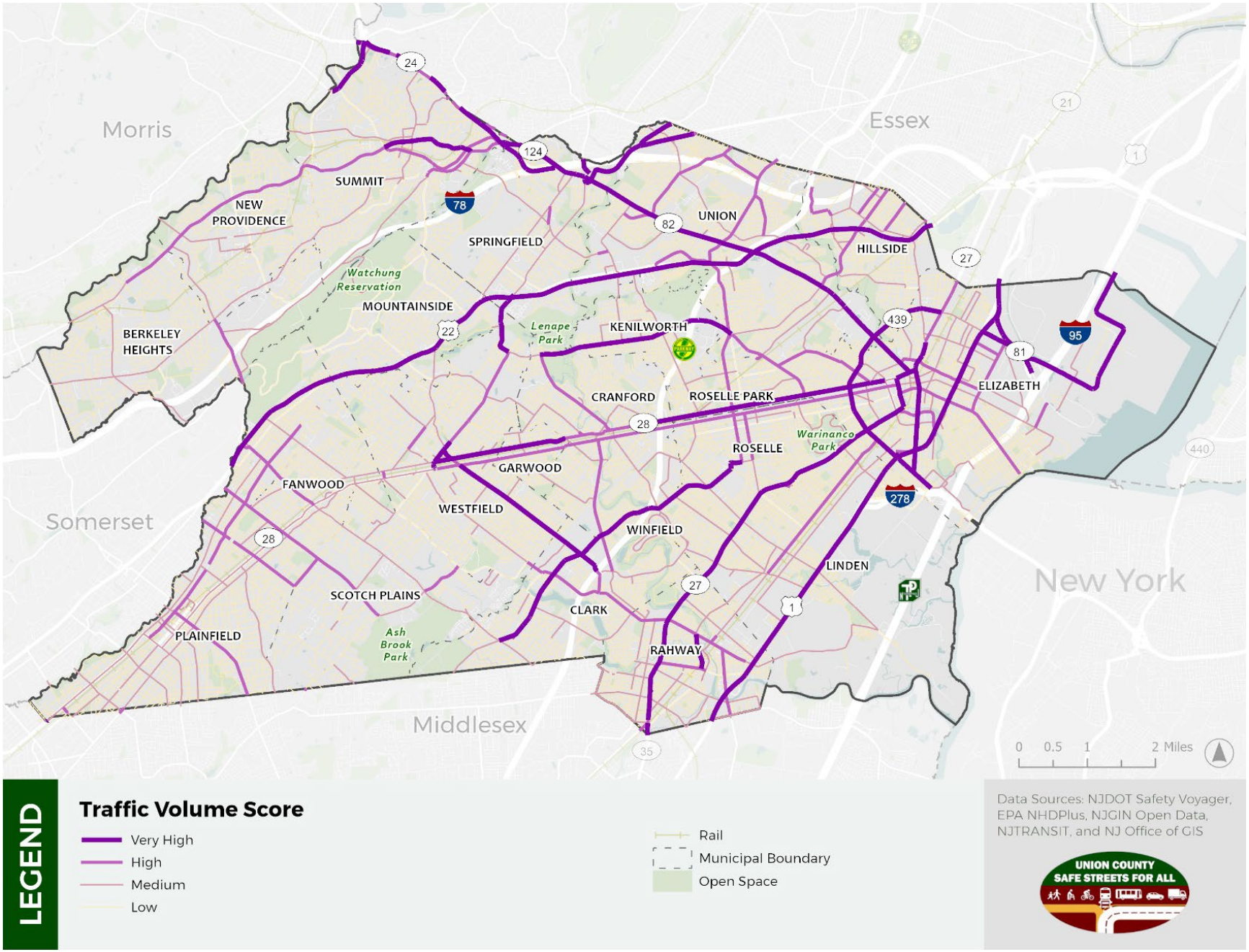
Figure 2 shows that Very High Risk segments are concentrated along major state arterials such as US 1&9, US 22, NJ 27, NJ 28, NJ 24, and NJ 81, which experience the county's highest traffic volumes. In addition, Kenilworth Boulevard, particularly west of Chestnut Street, stands out as a Very High Risk county route corridor. Central Avenue between Westfield and Clark also exhibits high traffic-related risk, along with Raritan Road between Clark and Roselle. In the northeast corner of the county, Corbin Street, a key freight connector to the port and interstate system, was identified as another high-risk corridor, reflecting its high-volume and freight-heavy usage.

Table 13: Traffic Volume Risk Level Summary

Centerline Mileage by Route Subtype			
Risk Level	**State Route**	**County Route**	**Local Route**
Low (0)	0 (0%)	44.8 (24%)	**1061.6 (90%)**
Medium (2)	8.3 (13%)	**80.1 (42%)**	93.1 (8%)
High (4)	4.5 (7%)	49.8 (26%)	17.3 (1%)
Very High (6)	**49.4 (79%)**	15.5 (8%)	6.5 (1%)

Max Points Possible: 6

Figure 2: Traffic Volume Score by Risk Level



HEAVY TRUCK TRAFFIC

For this risk category, the roadway segments fell into only two categories: Low Risk and High Risk. Table 14 shows that nearly all local roads (100%) and the vast majority of county routes (85%) scored as Low Risk, while 96% of state routes were classified as High Risk, highlighting their role as primary freight corridors. Only 4% of state routes fell into the Low Risk category.

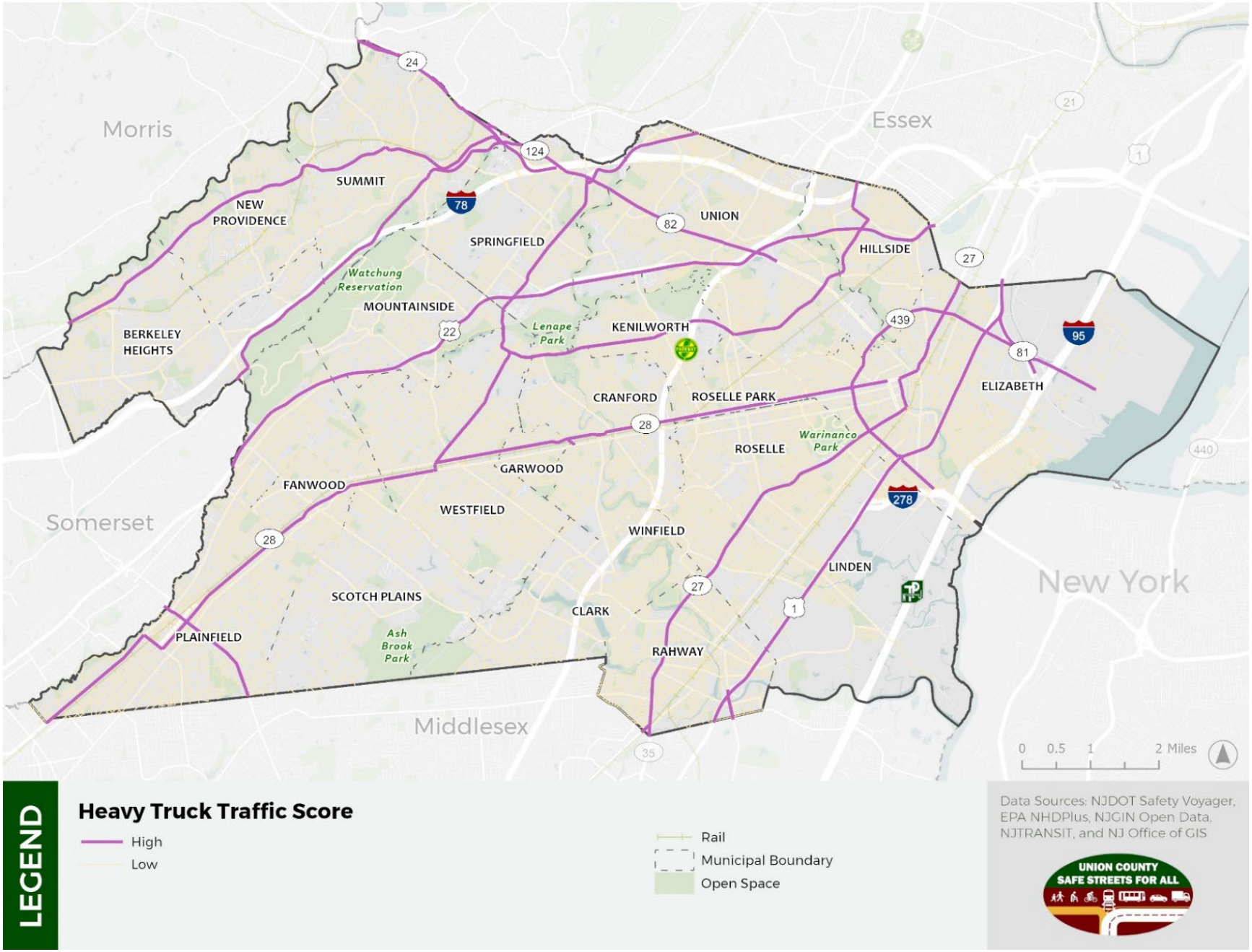
Figure 3 shows that freight-accessible routes are primarily located along state highways, including corridors such as US 1, US 22, NJ 27, NJ 28, NJ 439, and NJ 81, which carry the heaviest freight volumes. A few county roads also emerged as freight corridors, including Kenilworth Boulevard in Kenilworth, Park Avenue in Plainfield, and East Broad Street in Westfield.

Table 14: Heavy Truck Traffic Risk Level Summary

Centerline Mileage by Route Subtype			
Risk Level	**State Route**	**County Route**	**Local Route**
Low	2.5	**162.5**	**1176.0**
(0)	(4%)	**(85%)**	**(100%)**
High	**59.7**	27.7	2.5
(4)	**(96%)**	(15%)	(0%)

Max Points Possible: 4

Figure 3: Heavy Truck Traffic Score by Risk Level



VULNERABLE ROAD USER (VRU) GENERATORS

When evaluating risk based on the presence of VRU generators, Table 15 indicates that local routes had the highest proportion of Low Risk segments (87%), followed by county routes (67%) and state routes (54%). Very High Risk segments range from 1% on local roads to 8% on state routes.

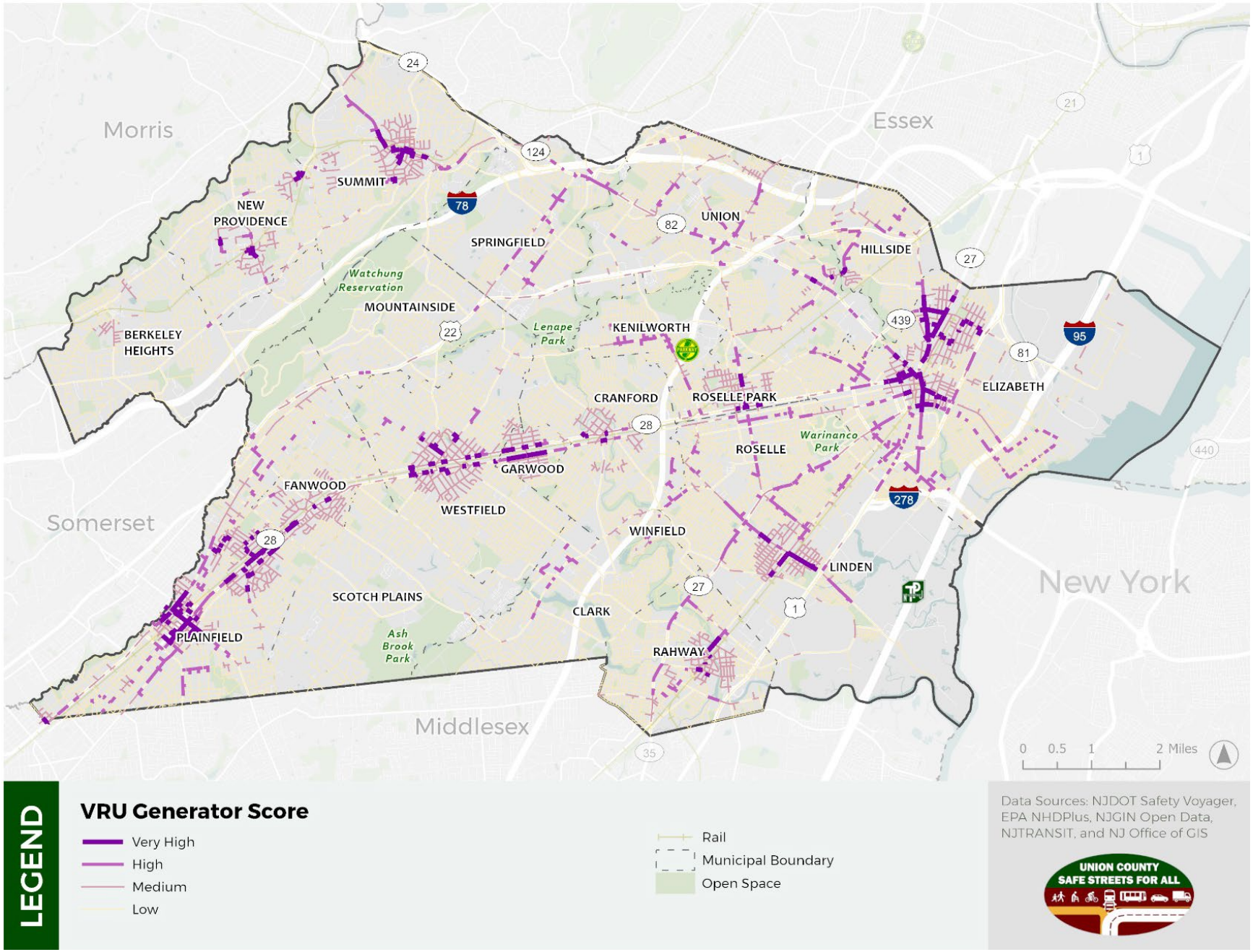
As shown in Figure 4, the spatial distribution of VRU-related risk reveals a radial pattern surrounding key VRU generators, particularly near town centers and train stations. High and Very High Risk segments are especially concentrated in the City of Elizabeth, Linden, Rahway, Roselle Park, Garwood, Westfield, Plainfield, and Summit, where pedestrian activity and transit access are more prominent.

Table 15: VRU Generators Risk Level Summary

Centerline Mileage by Route Subtype			
Risk Level	**State Route**	**County Route**	**Local Route**
Low (0-2)	**33.8 (54%)**	**126.7 (67%)**	**1020.8 (87%)**
Medium (4)	12.8 (21%)	35.1 (18%)	130.8 (11%)
High (6)	10.6 (17%)	20.1 (11%)	19.8 (2%)
Very High (8)	5.0 (8%)	8.2 (4%)	7.2 (1%)

Max Points Possible: 8

Figure 4: VRU Generators Score by Risk Level



Union County High Risk Network

The composite risk level results shown in Table 16, which combines all evaluated risk features, reveals that most of the local roadway mileage in Union County falls within the Low Risk or Medium Risk categories. Specifically, 83% of local road mileage and 18% of county route mileage are classified as Low Risk. In contrast, state routes dominate the higher risk categories. Approximately 75% of state route mileage are categorized as High Risk, with an additional 23% falling into the Medium Risk category. Only 2% of state route mileage qualify as Very High Risk, and there are no county or local roads assigned to this category.

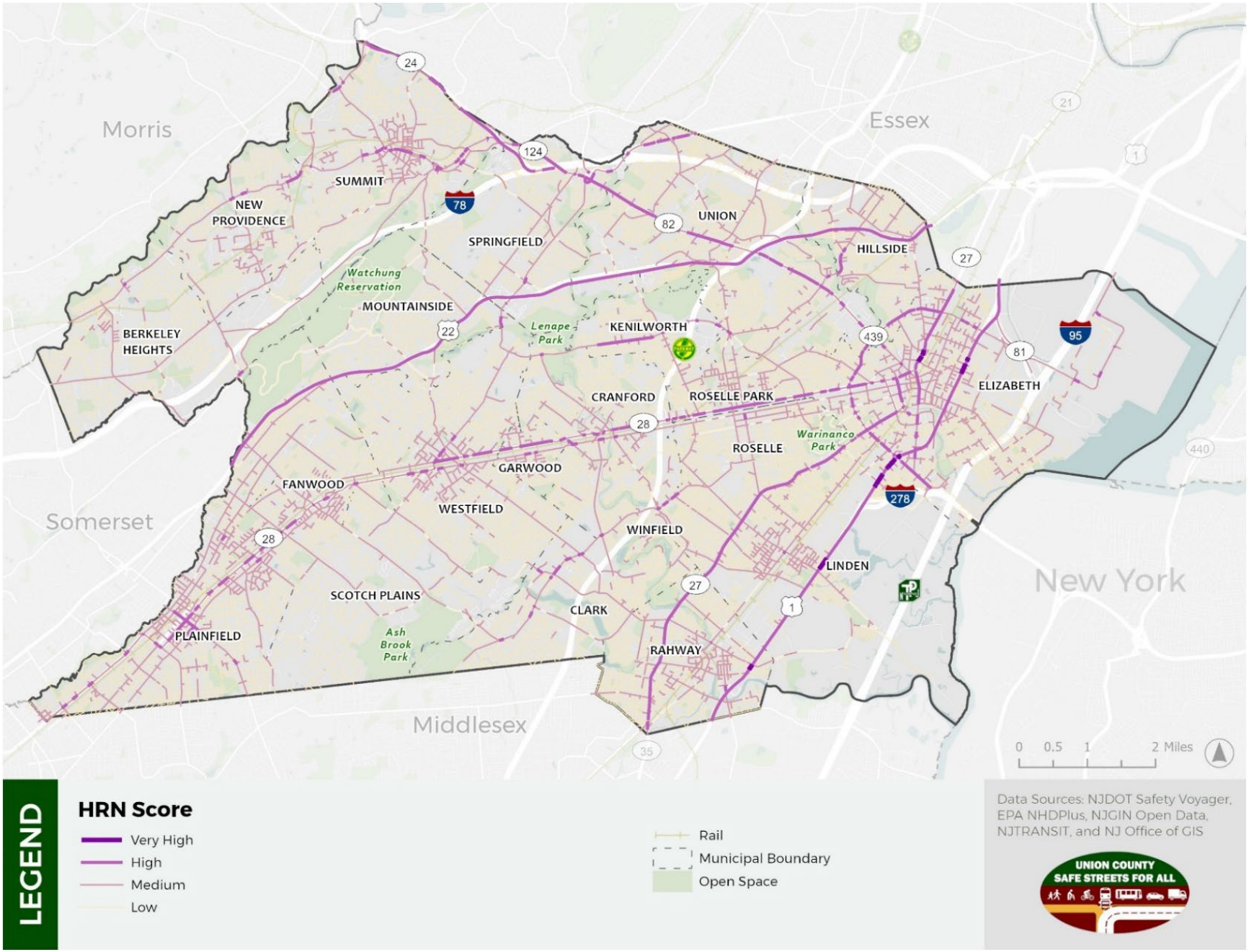
Figure 5 shows that Very High Risk corridors are primarily located along major state routes, including multiple segments of US 1&9 and NJ 27 (North Broad Street). These roads consistently exhibit elevated risk levels across multiple scoring dimensions. While state routes comprise the majority of high-risk corridors, there are also several key segments on county and local roads that scored highly. Notable examples include Springfield Avenue in Summit, Raritan Road traversing Clark and Winfield, and Park Avenue and Somerset Street in Plainfield. One particularly prominent corridor is Kenilworth Boulevard, which runs through the center of Kenilworth for approximately one mile and stands out due to its continuous high-risk designation.

Table 16: Composite Score Risk Level Summary (Union County)

Centerline Mileage by Route Subtype			
Risk Level	**State Route**	**County Route**	**Local Route**
Low (0-8)	0 (0%)	34.6 (18%)	**980.8 (83%)**
Medium (9-21)	14.1 (23%)	**146.2 (77%)**	197.2 (17%)
High (22-34)	**46.9 (75%)**	9.4 (5%)	0.6 (0%)
Very High (35-42)	1.2 (2%)	0 (0%)	0 (0%)

Max Points Possible: 42

Figure 5: HRN Score by Risk Level (Union County)



Elizabeth High Risk Network

A subset of the county-wide HRN was generated to focus on roadways located within the City of Elizabeth. Consistent with the county-level analysis, HRN scores for the city were categorized into four distinct risk levels. A corresponding summary table was prepared to present the composite risk scores.

Table 17 shows the mileage-based results for the City of Elizabeth, which reveals a distinct concentration of High Risk and Very High Risk segments on state- roadways. According to the risk distribution table, 71% of state route mileage within Elizabeth falls into the High Risk category, with an additional 24% classified as Medium Risk and 5% reaching the Very High Risk threshold. In contrast, the vast majority of local road mileage (66%) is classified as Low Risk, with the remainder falling primarily into the Medium Risk category. County routes in Elizabeth largely follow the same pattern, with 80% in the Medium Risk category and 11% considered High Risk.

The spatial distribution of risk shown in Figure 6 also reflects these patterns. All Very High Risk segments are located on state routes, specifically along US 1&9 and North Broad Street (NJ 27). Other segments of these same routes, as well as parts of NJ 439, also register as High Risk, consistent with their high volumes and roadway characteristics. Beyond state roads, Broad Street and Pearl Street, classified as county and local routes, feature isolated High Risk segments. Additionally, in the northeastern section of Elizabeth, several High Risk segments are found along connectors between the interstate system and the port facilities, reflecting the freight-heavy nature of that corridor and its elevated crash exposure.

Table 17: Composite Score Risk Level Summary (City of Elizabeth)

Centerline Mileage by Route Subtype			
Risk Level	**State Route**	**County Route**	**Local Route**
Low (0-8)	**0 (0%)**	**1 (9%)**	**85.2 (66%)**
Medium (9-21)	**3.1 (24%)**	**9.0 (80%)**	**44.0 (34%)**
High (22-34)	**9.0 (71%)**	**1.2 (11%)**	**0.5 (0%)**
Very High (35-42)	**0.6 (5%)**	**0 (0%)**	**0 (0%)**

Max Points Possible: 42

Figure 6: HRN Score by Risk Level (City of Elizabeth)