

Large and complex highway planning exercises often use travel demand forecasting models to help analyze the need for alternative highway investments. For Phase 1 of the US 64–NC 49 Corridor Study, the Study Team developed a transportation model as a forecasting tool that would be capable of producing reliable, order-of-magnitude estimates of both the potential increases in travel demand across the study area resulting from projected population and employment growth and the potential traffic diversion effects of providing additional highway capacity along the US 64–NC 49 Corridor. For these and other measures of effectiveness, the sketch-planning forecasting tool supplied information to confirm the need for congestion and mobility relief in the corridor and to judge the relative merits of the alternatives studied in addressing these needs.

6.1 Methodology

The US 64–NC 49 Corridor transportation model uses a conventional and sequential four-step process (trip generation, trip distribution, mode choice, and traffic assignment). The Study Team has implemented the travel demand forecasting model process in software using the TransCAD platform. TransCAD, NCDOT’s primary modeling software, is one of several commercially available software packages designed for customized travel demand forecasting of the type produced for this study.

As a way of simplifying the very complex factors underlying the region’s demand for travel, the model estimates the amount of all trip-making by trip purpose. Work and Non-Work travel with one end of the trip at home are considered separately, as are trips with neither end of a trip at home (Non-Home Based), long-distance travel (defined as travel greater than 100 miles), and travel starting and/or ending outside the state of North Carolina (defined as regional traffic). Truck travel is stratified by vehicle type: light, medium, and heavy trucks. While these categorizations are simplifications, they nonetheless allow for the development of a traffic forecasting model that is sensitive to the unique travel characteristics of the different travel markets that exist in the US 64–NC 49 regional study area.

The four-step process consists of the following basic elements.

- **Trip Generation:** Trip generation estimates the number of trips “produced” by households and “attracted” to shopping and job centers, without regard to the origin and destination of these trips. For non-truck travel, trip generation production rates are stratified by area type (Central Business District, urban and rural), auto ownership, and household size. Attraction rates are stratified by area type and seven employment types (retail, wholesale, service, construction, agriculture/forestry, transportation, and other). For truck travel, trip generation (attraction and production) rates are stratified by five categories of employment (agriculture/mining/construction, manufacturing/transportation/wholesale, retail, services, and other). The rates were derived from the National Cooperative Highway Research Program (NCHRP) 365 “Quick Response” manual.



- **Trip Distribution:** Trip distribution assigns a start and end point for each trip. The gravity model used in this study accounts for the distance between population and employment centers as well as the relative size of each location in developing production/attraction trip tables for each purpose. The gravity model used for trip distribution generates impedances using an exponential form, where the exponents have been derived (with slight modifications) from a statewide traffic forecasting model developed for the Missouri Department of Transportation (MODOT). The MODOT model includes trip table estimates based on information from a recently-completed statewide household interview survey for an area comparable to the model region for the US 64–NC 49 study. For this reason, the Study Team concluded the MODOT trip table estimates to be a reasonable proxy for the US 64–NC 49 model in the absence of statewide interview data for North Carolina. Trip tables are developed for all day travel, using appropriate production/attraction factors derived from NCHRP 365. The transportation model for this study was calibrated to average annual daily traffic conditions only.
- **Mode Split:** Traditionally, the mode split step assigns person trips to a mode of travel such as highway, bus, rail, high occupancy vehicle, etc, based on relative differences in travel time and cost for each mode. However, this model converts estimated person trips to highway vehicle trips only, through the application of trip-purpose specific vehicle occupancy factors derived from NCHRP 365.
- **Trip Assignment:** In trip assignment, vehicles choose their routes along the highway network based on their origin and destination, the travel time between origins and destinations via reasonable travel paths, and the level of congestion on the available roadways. Auto trips, light/medium truck trips, and heavy-duty truck trips are considered separately in this process.

6.2 Model Network

In its level of detail and sophistication, the transportation model was designed for consistency with the objectives of this phase of study. The model was constructed to capture changes in longer-distance (inter-urban) flows of autos and trucks that result from significant changes in highway capacity, household growth, and employment growth. In contrast, transportation models developed and used by Metropolitan Planning Organizations, such as those in Charlotte, the Triad, and the Triangle, are designed to capture traffic demand within a metropolitan region. They are designed to capture the impact of small scale changes in travel times and costs on travelers' mode of travel, their choice of routes, and their choice of destination.

The land use activities used in the trip generation step are represented as aggregated areas corresponding to 2000 US Census tract geography in a 24-county core model area (the previously defined 19-county primary corridor study area and the immediately adjacent counties that include major regional highway junctions/decision points) and as entire counties



in the rest of the state. In all, there are 904 traffic analysis zones, of which 740 lie within the core model area. The highway network in this expanded core area includes most roadway facilities up to and including the major collector functional classification. Outside of the 24-county area, the highway network includes only primary arterials such as the Interstate Highway System. These “non-core” areas are included in the US 64–NC 49 transportation model network in order to accurately capture the effects of through traffic volumes and other long-distance traffic flows. A number of external stations at key entry/exit points around the state are included as well.

6.3 Key Data Inputs

The TransCAD software and the four-step process provide a broad framework within which to construct the travel demand forecasting model for this study. The development process followed a series of stages that proceed in sequence. These stages are described below.

6.3.1 Data Collection

The two principal data requirements of the model are descriptions of land use and the regional highway network.

6.3.1.1 Land Use

The study required base (2002) and forecast (2030) year household and employment data. Base household data at the census tract level and county levels were derived from the 2000 US Census. Base year (2002) employment data were provided by InfoUSA, which provides marketing data on commercial establishments. The North Carolina Employment Security Commission assisted the Study Team in correcting various coding and processing errors in the employment data. For the travel demand forecasts, 2025 county-level employment forecasts by employment category and tract-level household forecasts were obtained from Global Insight, an economic forecasting firm. These forecasts were extrapolated to 2030 using trends developed by Global Insight.

6.3.1.2 Highway Network

The representation of the highway system in the transportation model requires that spatial coordinates be assigned to the start and end point of each roadway segment and that key attributes, such as functional classification, speed limit, capacity, and number of lanes, be assigned as well. These data were obtained from multiple sources, including the Federal Highway Administration’s Freight Analysis Framework and NCDOT’s asset management databases. NCDOT also supplied spatially referenced traffic counts, which the Study Team merged with the highway network file.



6.3.2 Build Highway Network

As noted above, the base year and forecast year highway networks used in the modeling exercise resulted from the merging of several databases, reports, plans, etc. Key data for the future highway network development came from NCDOT's Transportation Improvement Program along with the key elements of the Metropolitan Planning Organizations' and Rural Planning Organizations' long-range transportation plans and project priority lists, as described in Section 3.6.5. The Study Team and NCDOT collaborated closely to ensure that both the base year and forecast year highway networks accurately reflected the information obtained from all these sources. The highway networks must be sufficiently detailed to capture the diversion of traffic to alternative routes as congestion increases, ensure the roadway design speeds and capacities are accurate, and ensure there are no gaps or inconsistencies that skew the traffic forecasts. The Study Team conducted numerous tests and reviews of the initial traffic forecasts to ensure that the results obtained were valid and reliable. Tests conducted as part of the highway network building process include visual inspection of traffic volumes, a thorough review of individual trips between selected origins and destinations on the highway network, and a screening of travel times between all origins and destinations for unreasonable times.

6.3.3 Develop and Implement Model Process

The four-step model process described above was implanted as a single macro or "mini program" in the TransCAD software system. As a macro with a graphic user interface (GUI) the modeler can choose to execute one, several, or all steps in the model process and pair the highway network and land use data desired for an alternative test.

6.4 Model Calibration

The Study Team used the correspondence between year 2002 traffic counts obtained from NCDOT and year 2002 traffic simulation to assess the utility, reliability, and validity of the model as a forecasting tool. Numerous corrections and adjustments to the highway network's configuration were made as a result of these comparisons. Following these adjustments, the Study Team used a utility program in the TransCAD software package that adjusts the number of trips between origins and destinations so as to produce the best possible traffic assignment match to the traffic counts. More information on the model calibration process is available in the *US 64-NC 49 Corridor Study Model Calibration Technical Memorandum January 2005*.

Table 6.1 presents a comparison of the match between observed traffic counts and simulated traffic volumes in the core model area. The statistic used for this comparison, root mean square error (RMSE), measures the average error as a volume or as a percentage volume for each of nine daily volume ranges, from roadway segments with average daily volumes greater



than 100,000 vehicles per day (vpd) to roadway segments with average daily volumes under 2,500 vpd. **Table 6.1** shows that the percentage error generally increases as the volume range decreases, ranging from 2.6 percent for the highest range to 31.3 percent for the lowest.

Table 6.1: Model Calibration Results

Volume Range	Final Results		
	Number Counts	RMSE	% RMSE
Over 100,000	32	3,136	2.6
75,000-99,999	51	3,604	4.2
50,000-74,999	60	2,120	3.5
40,000-49,999	42	3,191	7.2
30,000-39,999	36	1,196	3.5
20,000-29,999	51	883	3.8
10,000-19,999	88	1,503	10.2
5,000-9,999	75	5,077	68.7
2,500-4,999	42	530	14.8
Under 2,500	28	413	31.3

6.5 Model Output

Following the model calibration, a series of 2030 travel demand forecasts were developed by matching the single projected set of household and employment forecasts with the regional highway system alternatives previously described in Chapter 5. All of the highway system alternatives described in Chapter 5 differed in the configurations of US 64 and NC 49 in the study corridor. The forecast households and jobs and all other components of the highway network remained constant for all the alternatives tested. All Build Alternatives were evaluated against a No-build or Baseline Alternative, for which no highway improvements were assumed on US 64 and NC 49. In order to assess the results of the travel demand forecasts according to the screening criteria developed for the study, model outputs were summarized in several ways. Some of the most important model outputs are described below.

6.5.1 Level of Service Comparison

For each alternative, color-coded volume bandwidth maps were developed directly from the travel demand modeling results for the forecast year 2030. The link color corresponds to the average daily highway level of service (LOS) and the width of the line on the map corresponds to the volume range. LOS is a measure of congestion which is usually measured



as a letter grade from A to F, with an “F” denoting significant levels of delay and congestion and an “A” denoting free-flow conditions. Maps for each of the alternative definitions evaluated for this study are provided in **Figures 6.1** through **6.5**. These maps allowed the Study Team to assess the relative congestion levels and traffic flows for each of the alternatives. In general, higher levels of investment produced higher volumes on US 64 and NC 49 and improved levels of service on I-40 and I-85.

6.5.2 Vehicle Hours of Travel at Level-of-Service F

Table 6.2 shows for each facility type in the transportation network, the percentage of total vehicle hours of travel (VHT) that is projected to operate at congested conditions (LOS F) in the year 2030. Systemwide, 37 percent of all VHT is forecast to operate in congested conditions by the year 2030, up from 14 percent in the base year (2002).

Table 6.2: Percent of VHT at LOS F (Baseline Alternative)

Facility Type	2002	2030
RURAL		
Interstate	10%	27%
Other Principal Arterials	2%	22%
Minor Arterials	7%	24%
All Others	18%	45%
URBAN		
Interstate	31%	54%
Other Freeways/Expressways	12%	34%
Other Principal Arterials	15%	45%
Minor Arterials	14%	23%
All Others	34%	75%
Network Total	14%	37%

Different highway functional classifications are projected to experience differing levels of congestion in the horizon year of 2030 as compared to the 2002 base year. For example, 27 percent of the VHT on “Rural Interstate” routes for the Baseline Alternative is projected to experience LOS F conditions in the year 2030, as compared to only 10 percent of VHT on these facilities in the base year of 2002 operating at this congestion level. Similarly, the percent of VHT operating at LOS F on “Other Principal Arterials” is projected to increase from two percent in 2002 to 22 percent in the year 2030

Figure 6.1: Level of Service and Volume Range Map for Baseline Alternative (Year 2030)

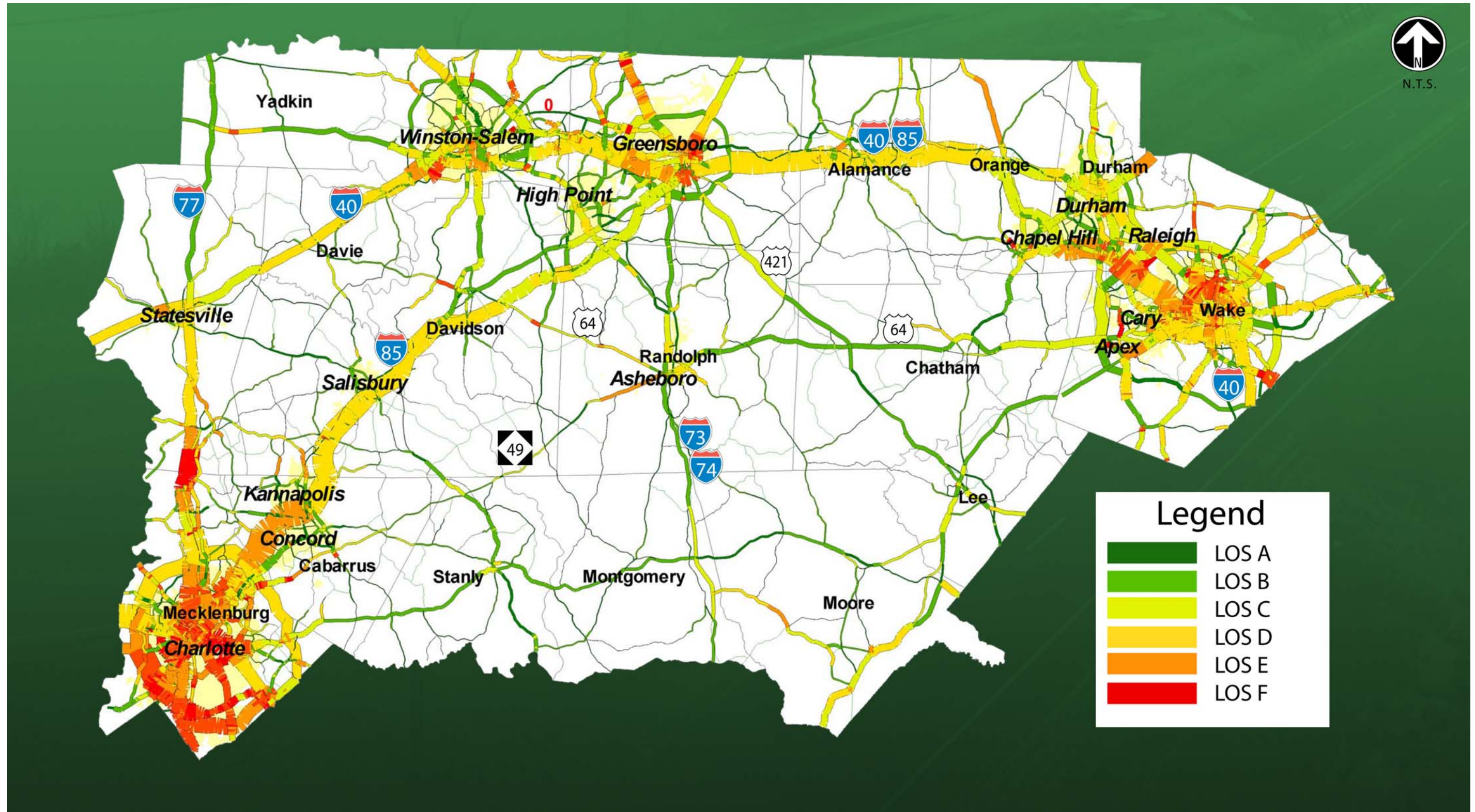


Figure 6.2: Level of Service and Volume Range Map for E+C Alternative (Year 2030)

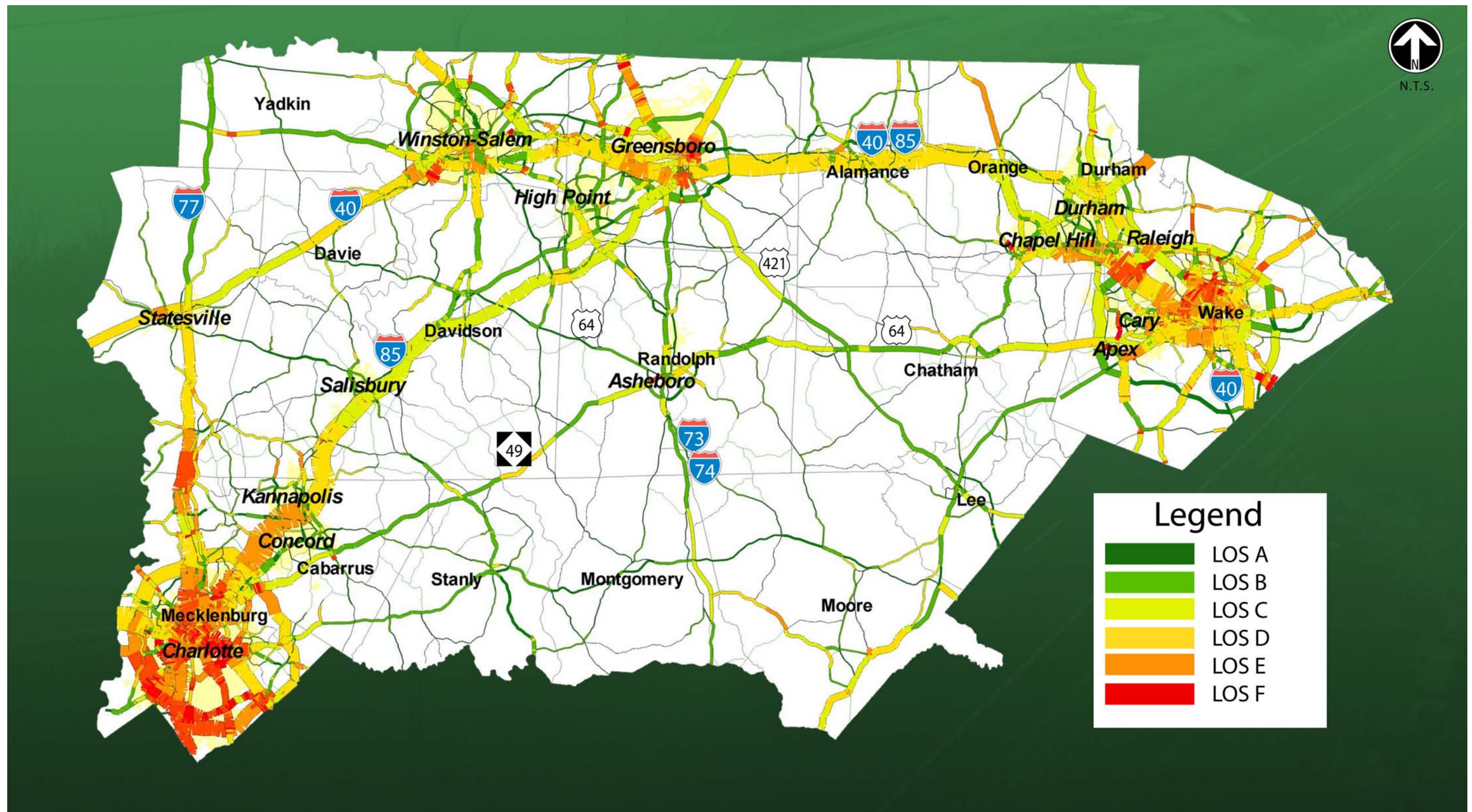


Figure 6.3: Level of Service Map and Volume Range for E+C Enhanced Alternative (Year 2030)

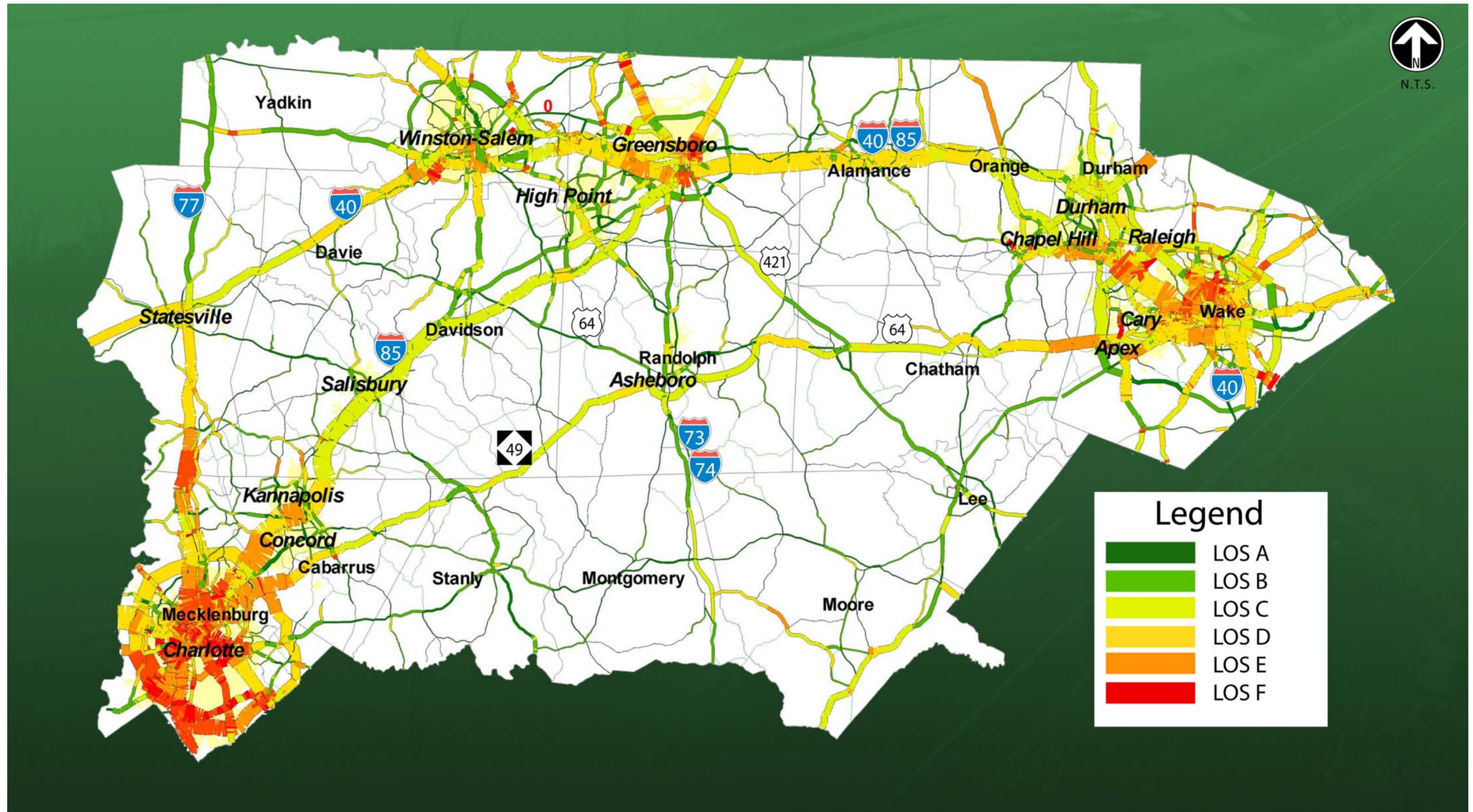


Figure 6.4: Level of Service and Volume Range Map for Expressway Alternative (Year 2030)

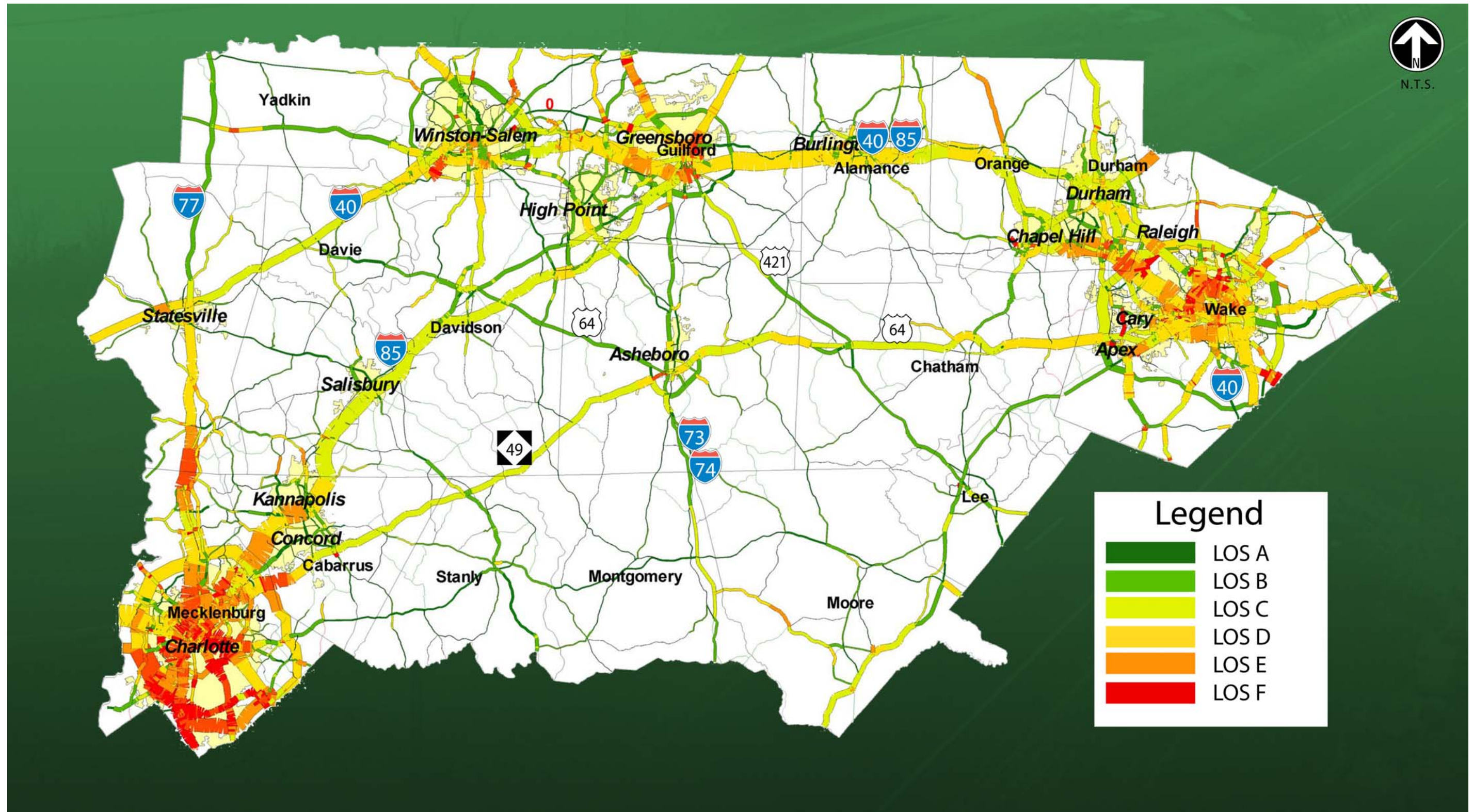
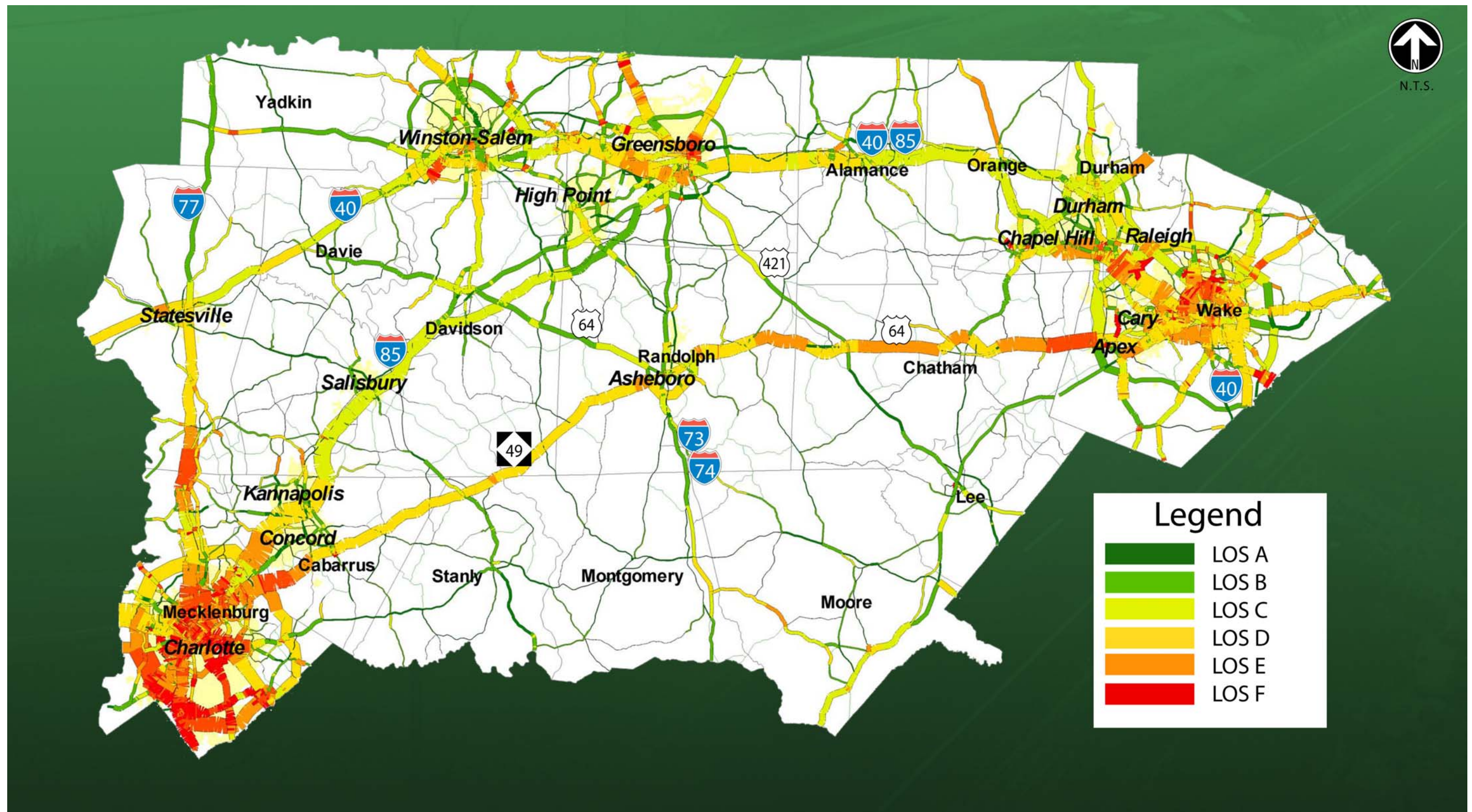


Figure 6.5: Level of Service and Volume Range Map for Freeway Alternative (Year 2030)



6.5.3 Screenline Analysis

Screenlines are imaginary lines, which cut across the principal arterial highways of interest to this study and which capture travel movement patterns between and among major activity centers in the core area. For this study, six north-south screenlines capturing east-west travel across the study area were developed. These screenlines are shown in **Figure 6.6**.

Figure 6.6: Study Area Screenlines

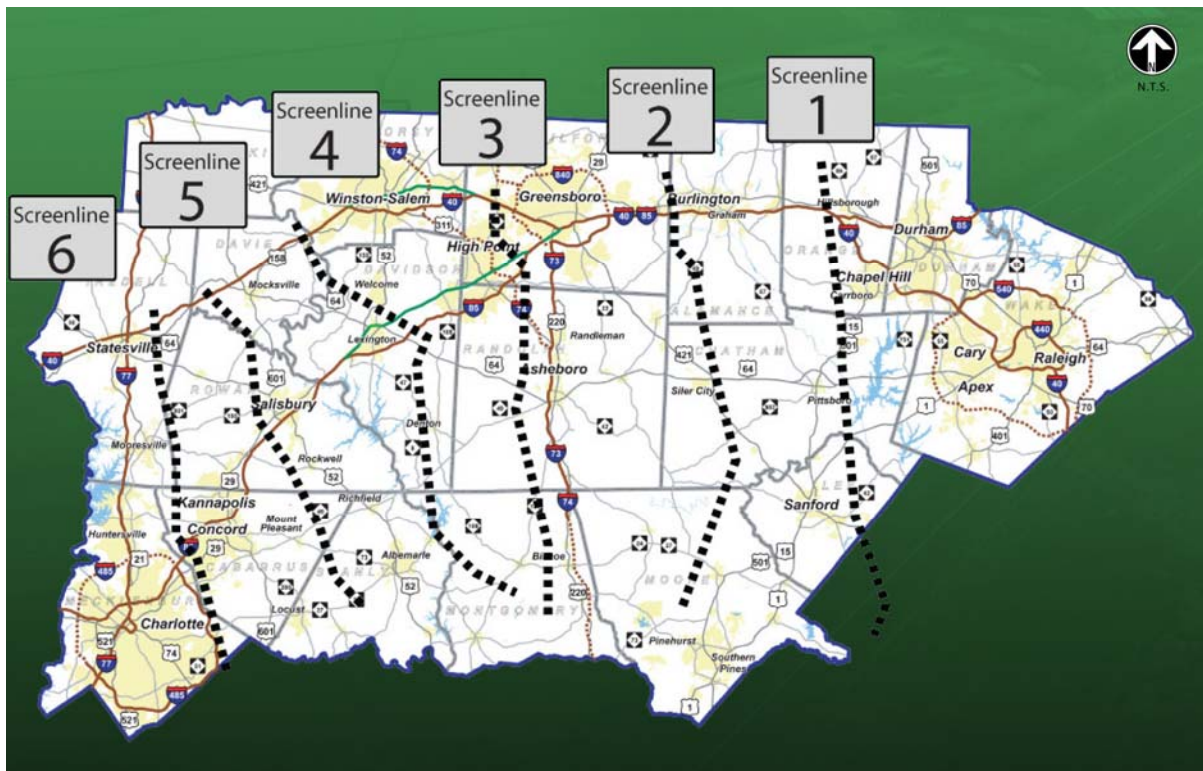


Table 6.3 presents forecast (year 2030) traffic volumes for a sampling of roads cut by the screenlines (including US 64 and NC 49) for each alternative. As shown in **Table 6.3**, the greater the speed and capacity of the US 64–NC 49 improvement alternative, the greater the volume of traffic that is projected to use the improved facility.



Table 6.3: Year 2030 Screenline Volumes by Alternative

Facility	No-Build (Baseline)	E + C	E+C Enhanced	Expressway	Freeway
Screenline 1 (Pittsboro-Raleigh)					
I-40/I-85	134,700	132,200	123,900	122,100	112,000
US-64	44,400	47,400	66,200	64,300	87,500
US-421	25,200	25,500	22,600	23,500	21,800
Screenline 2 (East of Ramseur)					
US-64	35,200	38,600	55,100	56,400	81,200
US-421	18,400	19,200	20,100	18,000	16,700
I-40/I-85	130,900	128,000	120,500	118,800	113,000
Screenline 3 (Between Winston-Salem and Greensboro)					
I-85	68,500	65,900	59,100	58,500	52,200
I-40	145,100	143,400	141,600	136,300	130,000
NC 49	33,900	44,800	62,200	60,100	82,500
US 64	10,900	15,900	17,300	29,600	42,200
Screenline 4 (West of Winston-Salem)					
I-40	94,600	94,000	92,200	85,900	79,300
I-85	84,200	80,900	73,100	73,200	65,900
NC 49	22,200	28,700	45,200	43,600	66,500
US 52	42,000	44,900	45,200	46,500	48,200
US 64	7,600	10,900	12,000	23,400	34,500
I-85 Bus.	26,900	27,000	27,000	28,800	31,100
Screenline 5 (South of Mocksville)					
I-40	57,700	57,400	55,800	58,400	59,600
I-85	118,900	115,000	107,900	107,400	100,300
NC 49	20,100	26,600	41,200	43,500	67,200
Screenline 6 (East of Charlotte)					
I-40	56,500	56,200	54,600	57,100	58,300
I-85	157,800	154,200	146,600	144,800	138,400
US 64	3,300	3,300	3,300	3,300	3,300
NC 49	42,500	52,700	80,700	81,300	98,600

6.5.4 Traffic Diversion

One of the primary evaluation criteria for this analysis is the potential for traffic diversion from I-40 and I-85 to the US 64–NC 49 Corridor. **Table 6.4** summarizes the screenline results and shows the magnitude of this diversion by alternative. All of the investment alternatives show the greatest potential for diversion around the Piedmont Triad, where clusters of development are closely spaced (Screenlines 3-4) and the least (percentage-wise) between Charlotte and Mocksville (Screenline 6). The E+C Enhanced Alternative and the Expressway Alternative show very similar results across all screenline locations.



Table 6.4: Traffic Diversion from I-40/I-85 to US 64–NC 49 by Alternative Relative to the Baseline Alternative

Screenline #	E+C		E+C Enhanced		Expressway		Freeway	
	vpd	%	vpd	%	vpd	%	vpd	%
1 I-40/I-85 (Pittsboro-Raleigh)	2,500	2%	10,800	8%	12,600	9%	22,700	17%
2 I-40/I-85 (East of Ramseur)	2,900	2%	10,400	8%	12,100	9%	17,900	14%
3 I-85 (Between Winston-Salem and Greensboro)	2,600	4%	9,400	14%	10,000	15%	16,300	24%
3 I-40 (Between Winston-Salem and Greensboro)	1,700	1%	3,500	2%	8,800	6%	15,100	10%
4 I-85 (West of Winston-Salem)	600	1%	2,400	3%	8,700	9%	15,300	16%
4 I-40 (West of Winston-Salem)	3,300	4%	11,100	13%	11,000	13%	18,300	22%
5 I-85 (South of Mocksville)	300	1%	1,900	3%	(700)	-1%	(1,900)	-3%
5 I-40 (South of Mocksville)	3,900	3%	11,000	9%	11,500	10%	18,600	16%
6 I-40 (East of Charlotte)	300	1%	1,900	3%	(600)	-1%	(1,800)	-3%
6 I-85 (East of Charlotte)	3,600	2%	11,200	7%	13,000	8%	19,400	12%
Overall	21,700	2%	73,600	8%	86,400	9%	139,900	15%

Overall, the E+C Alternative would only divert about two percent of projected year 2030 average daily traffic volumes from the I-40/I-85 Corridor to the US 64–NC 49 Corridor. Conversely, the higher investment levels associated with the E+C Enhanced, Expressway, and Freeway alternatives would divert, respectively, eight percent, nine percent, and 15 percent of the total daily traffic demand from the I-40/I-85 Corridor to the US 64–NC 49 Corridor.

6.5.5 User Benefits

User benefits estimate total costs to users of the transportation system, in term of travel time, accident, out-of-pocket, and operating costs. Travel time and VMT data were output from the traffic forecasting model for this analysis. Discussion of user benefits by alternative is provided in Chapter 7.

