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NC Strategic Transportation Corridors: Vision Plan

Baseline and Future Year Mobility Conditions

NCDOT

April 2020

Corridor D: U.S. 321

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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This document has 49 pages including the cover.

Document History

Revision	Purpose description	Originated	Checked	Reviewed	Authorized	Date
Rev 1.1	DRAFT #2	CRG	TDB	JWP	CW	24-03-2020
Rev 1.2	DRAFT #3	CRG	TDB	JWP	CW	08-04-2020

Client Signoff

Client	NCDOT
Project	Corridor D: U.S. 321
Job number	100066466
Client signature / date	

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1. Overview and Project Background

This memorandum presents base and future year mobility analyses for Corridor D of the North Carolina Strategic Transportation Corridors (STC).

1.1. Overview of Strategic Transportation Corridors

In 2015, the North Carolina Department of Transportation (NCDOT) identified a network of key multimodal transportation corridors called Strategic Transportation Corridors to support smart planning, help set long-term investment decisions, and ensure that North Carolina's economic prosperity goals are achieved. The STCs are intended to promote transportation system connectivity, provide high levels of mobility, and improve access to important state and regional activity centers. A key element in the advancement of the STCs is the development of corridor master plans, to identify a high-level corridor mobility vision and associated corridor improvement action strategies.

The purpose of the master plan is to:

- identify a mobility vision and broad improvement strategies for an entire corridor,
- guide improvements and development in a manner that defines a long-term vision and performance level for the corridor, and
- help protect the corridor's key functions as defined in the corridor profiles.

1.2. Corridor Description

The 106-mile Corridor D - U.S. 321, which stretches from the South Carolina state line to the Tennessee state line, serves Gaston, Lincoln, Catawba, Burke, Caldwell, Watauga, and Avery counties. U.S. 321 is part of a longer corridor providing access from external activity centers such as Columbia, South Carolina; Savannah, Georgia; and Johnson City, Tennessee. U.S. 321 carries high passenger and truck traffic between Corridor Q (I-40) in Hickory and Corridor I (I-85) in Gastonia. U.S. 321 also includes the CSX railroad that traverses the northern North Carolina mountains to the coal fields of the Appalachians. To the northwest, the corridor overlaps Corridor E (U.S. 421) for 7 miles.

2. Highway Mobility

Highway Mobility was analyzed for U.S. 321 for existing and future conditions based on the relationship of travel speed, congestion, and travel time. Existing conditions data was based on NCDOT traffic count data, GIS data, and third-party data (Google Maps satellite and travel time data). Future conditions analysis was based on the NC Statewide Travel Demand Model (NCSTM), Regional and Small Area Travel Demand Models, the Statewide Transportation Improvement Program (STIP), and Transportation Plans for communities through the corridor.

2.1. Existing Conditions Analysis

Existing conditions analysis was completed using 2018 NCDOT Average Annual Daily Traffic (AADT) Segment Data, 2019 NCDOT Route Characteristics Data, the NCSTM, and third-party data, including Google Maps. This section presents the process of identifying corridor segments and preparing mobility measures.

2.1.1. Definition of Segments

To manage the analysis of the project corridor, the corridor was divided into mobility segments. These segments represent sections that are generally homogenous and/or represent a uniform cross-section of roadway. The process of identifying segments included the review of the following attributes along the corridor:

- Major changes in roadway characteristics (cross-section, facility type, lanes)
- NCDOT Divisional Boundaries
- Interstate Crossings
- Metropolitan Planning Organization (MPO) Model boundaries
- Urban/rural transition

Segment breaks were not created for every occurrence of these characteristics; for example, small segments were avoided unless it was justified based on the uniqueness of the roadway attributes in that section. Although speed limits were a consideration, other factors were considered more heavily due to the frequency of speed limit changes.

A total of nine segments were identified for U.S. 321, as shown in **Table 1** and **Figure 1**. These segments varied in length from 3 miles to 34 miles. Analysis was completed for these segments based on AADT information, NCDOT systems level planning capacities, NCSTM analysis, and MPO model analysis.

Average 2018 AADT is based on NCDOT AADT segment data, which contains different segments than the mobility segments previously defined for U.S. 321. To determine the mobility segment's AADT, the 2018 NCDOT AADT data was averaged based on the length of the AADT segments within each mobility segment. 2018 AADT ranges and average AADT are presented in **Table 1**.

Table 1. U.S. 321 Mobility Segments

Segment	From	To	Length (miles)	Division	2018 AADT Range	Average 2018 AADT
101	SC State Line	Gastonia (Hudson Blvd)	6	12	8,500-18,000	11,440
102	Gastonia (Hudson Blvd)	Gastonia (I-85)	4	12	7,900-23,500	15,630
103	Gastonia (I-85)	Hickory (U.S. 70)	34	12	30,000-51,000	36,780
104	Hickory (U.S. 70)	Catawba River	3	12	35,000-43,500	38,120
105	Catawba River	Lenoir (SW Blvd)	10	11	29,500-43,500	32,540
106	Lenoir (SW Blvd)	N.C. 90/Main St	6	11	16,000-35,000	24,630
107	N.C. 90/Main St	Blowing Rock (Alt 321)	17	11	6,900-13,500	8,970
108	Blowing Rock (Alt 321)	U.S. 421/King St	9	11	10,500-44,000	20,140
109	U.S. 421/King St	TN State Line	18	11	2,700-16,500	6,650

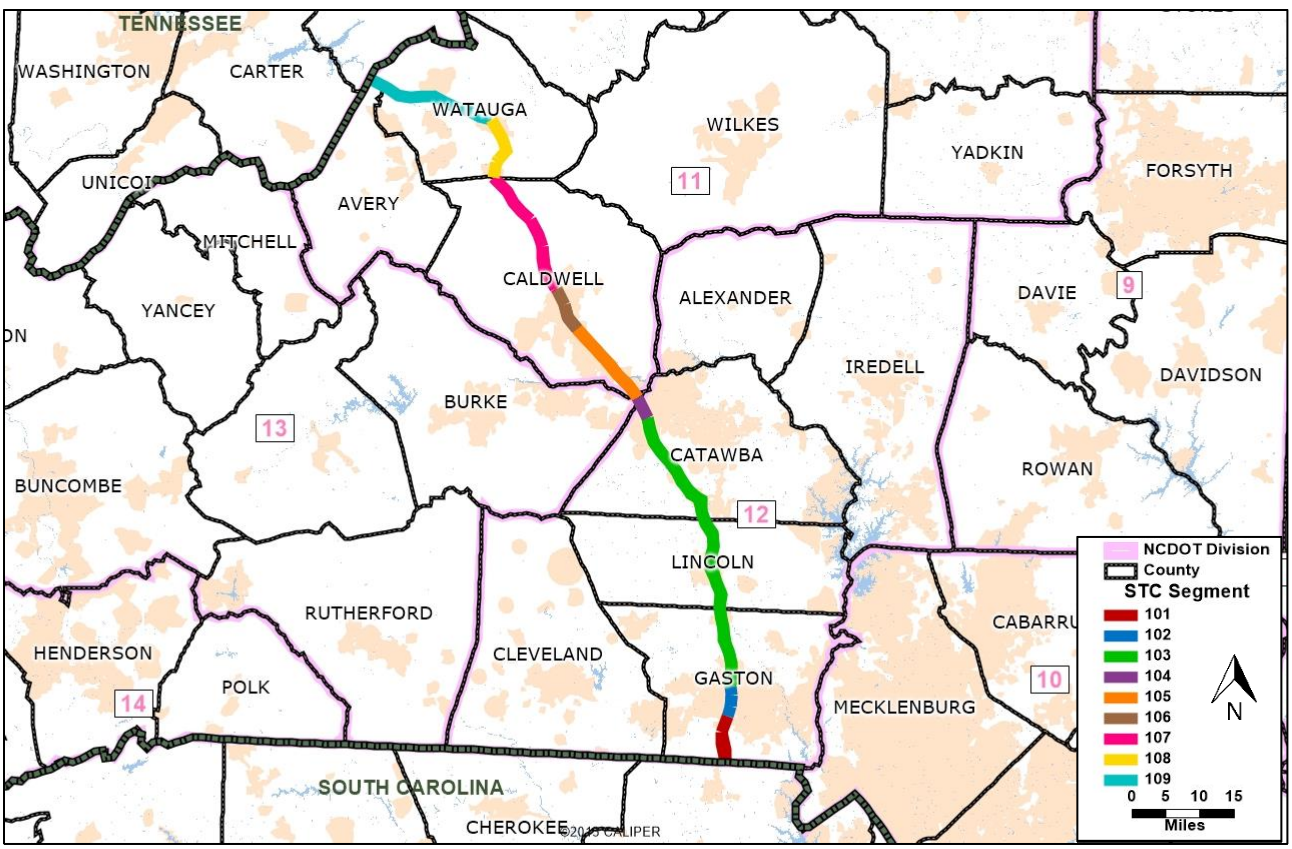

Figure 1. Corridor Segments

2.1.2. Segment Capacity and Travel Time

Typical planning-level highway capacity was developed for each segment along the corridor using the predominant cross-section representative of each segment. Capacities are based on NCDOT TPD's **Level of Service D Standards for Systems Level Planning**, updated 10/14/2011, as shown in **Appendix A**. Segment facility type, typical number of lanes, area type, percent trucks, terrain, and travel speed were used to identify the daily planning-level capacity for comparison against existing traffic. Segment capacities are shown in **Table 2**.

Travel times were calculated based on a weighted average of posted speeds for each segment (by length), existing volume-to-capacity ratios, and a volume-delay curve like what is used in the NCSTM. **Table 2** presents the travel time needed to fully utilize each segment. As a point of comparison, Google Maps travel times were identified for each segment to provide "observed" ranges based on third party data.

Table 2. Segment Capacities and Travel Times

Segment	Facility Type	Typical Speed (miles per hour)	Lanes	Median Type	Area Type	Planning Capacity	2018 Travel Time (Estimated) (min.)	Travel Time (Google Maps) (min.)
101	Major Thoroughfare	45	4	CLTL[1]	Suburban	30,800	8	8-12
102	Major Thoroughfare	35	4	None	Urban	21,500	7	6-12
103	Freeway	65	4	Divided	Suburban	58,500	32	30-40
104	Boulevard	45	4	Divided	Urban	35,100	5	4-10
105	Boulevard	45	4	Divided	Suburban	36,600	18	12-20
106	Major Thoroughfare	45	4	CLTL	Suburban	26,700	10	7-12
107	Major Thoroughfare	55	4	None	Rural	29,200	20	20-24
108	Major Thoroughfare	40	4	None	Rural	28,300	15	12-22
109	Minor Thoroughfare	40	2	None	Rural	15,500	29	26-35

1. CLTL = Continuous Left-Turn Lane

2.2. Future Conditions Analysis

Future conditions analysis was completed using growth rates developed for the corridor based on historical count data, the NCSTM, and relevant regional, MPO, and small area models. Two future scenarios were analyzed:

- 2040 Existing plus Committed (E+C): Existing network plus committed (in the 2020-2029 STIP with either Right-of-Way/Construction funding) corridor projects
- 2040 Recommended (Metropolitan Transportation Plan [MTP]/Comprehensive Transportation Plan [CTP]): E+C plus recommended MTP/CTP projects

Typically, these projects are on the corridor itself; however, if the project is on a parallel facility and is of regional significance, it was included in the future conditions analysis. For each scenario, annual growth rates for each segment were prepared to project 2018 AADT to 2040. Using this information, future volume-to-capacity (V/C), travel time, average speed, vehicle-miles traveled (VMT), and vehicle-hours traveled (VHT) were calculated for each segment and the entire corridor.

2.2.1. Committed and Recommended (MTP/CTP) Projects

For the 2040 E+C scenario, committed projects are those which were programmed in the 2020-2029 STIP that are regional in nature. **Table 3** shows projects included in the 2040 E+C evaluation. In the 2040 NCSTM, these projects were included in the analysis, along with other projects statewide that were included in the 2040 E+C network.

Table 3. 2040 E+C Scenario Projects

STIP ID	Segment	Counties	Roadway	Location/Description
U-4700	104/105	Burke/Caldwell/ Catawba	U.S. 321	North of U.S. 70 in Hickory to SR 1933 (SW Blvd). Widen to Six Lanes.
R-3430	n/a	Burke/Caldwell	SR 1001	U.S. 70 to SR 1933 (SW Blvd) in Lenoir. Widen to Multi-lanes.
R-2615	109	Watauga	U.S. 421/U.S. 321	U.S. 321/U.S. 421 Junction near Vilas to SR 1107 (105 Bypass). Widen to Multi-Lanes
R-5903	n/a	Watauga	U.S. 421	Tennessee Line to U.S. 321/U.S. 421 Junction near Vilas. Widen to Multi-Lanes

For the 2040 Recommended scenario, projects from area MTPs and CTPs were included in the project analysis. **Table 4** shows projects included for the 2040 Recommended scenario. Note: Some projects are consolidated/summarized where a group of individual grade separations/interchanges serve to convert a boulevard/expressway to interstate freeway standards.

Table 4. 2040 Recommended Scenario Projects

Plan	Segment	Counties	Roadway	Location/Description
MTP	101/102	Gaston	York Rd	From Beam St to Carolina Ave. Add Median.
MTP	101	Gaston	U.S. 321	From 19th Ave to Clyde St. Add Median.
MTP	107	Caldwell	U.S. 321	From Blackberry Rd to Watauga County Line. Widen to 4 Lanes.
MTP	105	Caldwell	U.S. 321	Dudley Shoals Rd (SR 1002). Add SB ramp to U.S. 321.
CTP	101	Gaston	U.S. 321	From SC State Line to south of W 10th Ave. Upgrade Access Management.
CTP	101	Gaston	U.S. 321	Proposed Gaston Parkway (near Davis Heights Dr). New facility/interchange with U.S. 321.
CTP	103	Gaston	U.S. 321	From I-85 to N.C. 275/279. Upgrade to Freeway.
CTP	n/a	Gaston	Northwest Bypass	New freeway bypass from I-85 near Bessemer City to U.S. 321 north of Dallas.
CTP	n/a	Gaston	Gaston Parkway	New freeway bypass from I-85 near Bessemer City to N.C. 279 (S New Hope Rd).
CTP	104/105/106	Caldwell	U.S. 321	U.S. 70 to U.S. 64. Upgrade to Expressway.
CTP	107	Watauga	U.S. 321	From Caldwell County Line to U.S. 221. Upgrade to Expressway, Widen to Multi-Lanes.
CTP	108	Watauga	U.S. 321/221	From U.S. 221 to Proposed U.S. 421 Bypass (near Fairway Dr). Upgrade to Expressway.
CTP	108	Watauga	U.S. 321	From proposed U.S. 421 Bypass to E King St. Convert to Boulevard.
CTP	108	Watauga	U.S. 321	Proposed U.S. 421 Bypass. New facility/interchanges.
CTP	109	Watauga	U.S. 321/421	From N.C. 105 Bypass to U.S. 421. Widen to 4 Lanes Divided.
CTP	109	Watauga	U.S. 321	From U.S. 421 to Avery County Line. Upgrade to Expressway.

2.2.2. Existing and Future Cross-Sections

With the buildout of committed and recommended projects, the characteristics of each segment along the corridor change over time, typically resulting in higher throughput capabilities and increased travel speeds. **Table 5** summarizes the facility type, lanes, and typical posted speed for 2018, 2040 E+C and 2040 Recommended conditions (shaded grey fields indicate a change from 2018).

Table 5. Volume-to-Capacity Ratios by Scenario

Seg-ment	2018 Conditions			2040 E+C Conditions			2040 Recommended Conditions		
	Facility Type	Typical Posted Speed (miles per hour)	Lanes	Facility Type	Typical Posted Speed (miles per hour)	Lanes	Facility Type	Typical Posted Speed (miles per hour)	Lanes
101	Major Thoroughfare	45	4	Major Thoroughfare	45	4	Boulevard	45	4
102	Major Thoroughfare	35	4	Major Thoroughfare	35	4	Major Thoroughfare	35	4
103	Freeway	65	4	Freeway	65	4	Freeway	65	4
104	Boulevard	45	4	Boulevard	45	6	Expressway	55	6
105	Boulevard	45	4	Boulevard	45	4	Expressway	65	4
106	Major Thoroughfare	45	4	Major Thoroughfare	45	4	Expressway	55	4
107	Major Thoroughfare	55	4	Major Thoroughfare	55	4	Expressway	55	4
108	Major Thoroughfare	40	4	Major Thoroughfare	40	4	Expressway	55	4
109	Minor Thoroughfare	40	2	Minor Thoroughfare	40	2	Boulevard	50	4

2.2.3. Travel Demand Model Analysis

Travel Demand Model Analysis was completed using the NCSTM, the Metrolina Regional Model (MRM), the Hickory Travel Demand Model, and the Boone Travel Demand Model. Data from each of these models was used to calculate growth rates. **Table 6** presents an example of NCSTM model output from the 2015 and 2040 E+C network.

Table 6. 2015/2040 NCSTM E+C Comparison

	2015 NCSTM Data				2040 E+C NCSTM Data			
Segment	Average AADT[1]	Daily VMT[2]	Daily VHT[3]	Ave. Speed	Average AADT	Daily VMT	Daily VHT	Ave. Speed
101	12,000	71,400	1,600	46	18,000	104,000	2,300	46
102	18,000	65,800	1,900	35	22,000	78,500	2,300	34
103	41,000	1,411,200	24,000	59	54,000	1,826,900	33,900	54
104	52,000	138,700	3,300	42	59,000	158,200	3,600	44
105	37,000	383,400	9,200	42	43,000	449,900	13,400	34
106	27,000	154,300	3,800	40	35,000	195,600	5,600	35
107	24,000	416,100	8,400	50	39,000	669,400	17,100	39
108	22,000	186,700	4,700	40	33,000	276,800	11,600	24
109	13,000	234,000	5,900	39	20,000	358,100	10,800	33
Total	**29,000**	**3,061,600**	**62,800**	**49**	**39,000**	**4,117,400**	**100,600**	**41**

1. AADT = Average Annual Daily Traffic
2. VMT = Vehicle-Miles Traveled
3. VHT = Vehicle-Hours Traveled

For the regional/MPO/local models, an E+C scenario was not evaluated; rather, the adopted MTPs were utilized for future year analysis. Information from these models was used to support development of growth rates to apply to each segment. **Table 7** shows a comparison of regional/MPO/local model data. When comparing growth data from the NCSTM and MPO models, it should be noted that corridor segments may be represented in multiple MPO models or only partially represented.

Table 7. Base Year (BY) and Future Year (FY) Conditions, MPO Model Output

				BY Data				FY Data			
Seg-ment	**Travel Demand Model(s)**	**BY**	**FY**	**Ave. AADT**	**Daily VMT**	**Daily VHT**	**Ave. Speed**	**Ave. AADT**	**Daily VMT**	**Daily VHT**	**Ave. Speed**
101	Metrolina Regional Model (MRM)	2015	2045	13,100	75,700	1,700	45	15,500	89,600	2,000	44
102	MRM	2015	2045	14,800	52,100	1,800	29	16,700	59,000	2,100	28
103	MRM	2015	2045	27,900	556,900	9,500	59	40,000	798,400	13,800	58
103	Hickory	2015	2045	26,400	367,200	6,100	60	36,800	511,000	11,200	46
104	Hickory	2015	2045	44,000	116,800	3,400	34	64,800	172,000	3,200	53
105	Hickory	2015	2045	36,000	376,900	7,400	51	47,300	494,600	8,900	55
106	Hickory	2015	2045	20,800	116,900	2,600	45	24,300	136,200	3,000	45
107	Hickory	2015	2045	9,600	157,800	2,700	58	9,800	162,200	2,800	59
108	Watauga*	2010	2040	19,000	119,000	-	-	25,000	156,400	-	-
109	Watauga*	2010	2040	11,000	105,100	-	-	13,500	128,200	-	-

*VHT/Speed data not readily available from Watauga Model

2.2.4. Projected Growth Rates

Projected growth rates were developed based on information from the NCSTM, MPO models, and relevant traffic forecasts by corridor segment. These growth rates will be applied to 2018 segment AADT to determine future year AADT for each scenario for mobility analysis. **Table 8** shows the projected growth rate for each corridor segment.

Table 8. Projected Growth Rates by Segment

	NCSTM		MPO	STC Growth Rate	
Segment	**Annual Growth Rate, 2015-2040 E+C**	**Annual Growth Rate, 2015-2040 Rec.**	**Annual Growth Rate**	**E+C, Selected**	**Recommended, Selected**
101	1.6%	1.9%	0.6%	1.5%	1.8%
102	0.8%	1.6%	0.4%	1.2%	1.5%
103	1.1%	1.6%	1.2%	1.1%	1.5%
104	0.5%	1.4%	1.3%	1.0%	1.4%
105	0.6%	2.3%	0.9%	0.8%	1.5%
106	1.0%	2.8%	0.5%	0.8%	1.5%
107	2.0%	2.4%	0.1%	1.2%	1.5%
108	1.6%	2.1%	0.9%	1.2%	1.6%
109	1.7%	2.7%	0.7%	1.5%	2.0%

2.3. Mobility Measures

While there are many mobility measures that can be considered for each corridor based on quantitative and qualitative data, this mobility analysis is based on the relationship of travel speed, congestion, and travel time. For each scenario, a projected volume was compared against available capacity to estimate the travel time. VMT, VHT, and average speed are also presented for each scenario.

2.3.1. Volume-to-Capacity Ratio

Volume-to-Capacity (V/C) Ratio is a representation of a daily planning-level capacity versus an average daily traffic volume. It is not a measure of peak traffic or congestion, but rather an overall measure of the how well the roadway will function over the course of a day. Segments with a V/C exceeding 1.0 are considered LOS E in this analysis. **Table 9** presents V/C ratios by scenario. Shaded E+C and Recommended fields reflect increased capacities due to E+C/MTP/CTP projects.

Table 9. Volume-to-Capacity Ratios by Scenario

Segment	2018 Conditions			2040 E+C Conditions			2040 Recommended Conditions		
	Average Volume	Typical Capacity	Average V/C	Average Volume	Typical Capacity	Average V/C	Average Volume	Typical Capacity	Average V/C
101	11,440	30,800	0.37	15,870	30,800	0.52	16,940	36,600	0.46
102	15,630	21,500	0.73	20,320	21,500	0.95	21,690	23,500	0.92
103	36,780	58,500	0.63	46,790	58,500	0.80	51,030	58,500	0.87
104	38,120	35,100	1.09	47,450	52,800	0.90	51,760	69,500	0.74
105	32,540	36,600	0.89	38,770	36,600	1.06	45,150	57,100	0.79
106	24,630	26,700	0.92	29,350	26,700	1.10	34,180	57,100	0.60
107	8,970	29,200	0.31	11,660	29,200	0.40	12,450	57,400	0.22
108	20,140	28,300	0.71	26,180	28,300	0.93	28,560	57,400	0.50
109	6,650	15,500	0.43	9,230	15,500	0.60	10,280	42,900	0.24

2.3.2. Average Travel Time and Speed

Average travel time and speed are measures of the relationship between the V/C ratio of a segment and its typical travel speed. Volume-delay curves by facility type were used to estimate travel time and speed. These volume-delay curves, based on adjusted NCSTM volume-delay function (VDF) curves, represent the typical "congested" speed on a daily planning level. These travel times are not representative of any individual trip, since over the length of the entire corridor an individual traveler could pass through a segment at an off-peak or peak time. **Table 10** shows average travel time and speeds by scenario.

Table 10. Average Travel Speed and Travel Time by Scenario

Segment	2018 Conditions			2040 E+C Conditions			2040 Recommended Conditions		
	Typical Posted Speed (miles per hour)	Average Travel Speed (miles per hour)	Average Travel Time (min)	Typical Posted Speed (miles per hour)	Average Travel Speed (miles per hour)	Average Travel Time (min)	Typical Posted Speed (miles per hour)	Average Travel Speed (miles per hour)	Average Travel Time (min)
101	45	42	8.2	45	41	8.5	45	41	8.4
102	35	30	7.2	35	27	8.1	35	27	8.0
103	65	65	31.6	65	63	32.2	65	62	33.0
104	45	30	5.2	45	35	4.5	55	54	2.9
105	45	35	17.8	45	31	20.1	65	64	9.9
106	45	35	9.7	45	30	11.2	55	55	6.1
107	55	52	19.6	55	51	20.0	65	65	18.6
108	40	34	14.9	40	31	16.6	55	55	9.3
109	40	37	28.8	40	34	31.2	50	48	22.0
Total Travel Time			**143.2**			**152.4**			**118.3**

2.3.3. Vehicle-Miles and Vehicle-Hours Traveled

VMT and VHT represent overall demand on each segment for each scenario. **Table 11** shows a summary of VMT and VHT for each project scenario.

Table 11. VMT and VHT by Scenario

Segment	2018 Conditions		2040 E+C Conditions		2040 Recommended Conditions	
	VMT	VHT	VMT	VHT	VMT	VHT
101	66,000	1,600	91,500	2,200	97,700	2,400
102	55,900	1,900	72,700	2,700	77,600	2,900
103	1,253,600	19,300	1,594,800	25,100	1,739,300	28,100
104	101,400	3,300	126,200	3,600	137,700	2,500
105	341,500	9,600	406,900	13,000	473,800	7,500
106	138,200	4,000	164,700	5,500	191,800	3,500
107	153,200	2,900	199,200	3,900	212,700	3,900
108	171,400	5,000	222,800	7,300	243,100	4,400
109	117,400	3,200	162,900	4,800	181,400	3,800
Total	**2,398,600**	**50,800**	**3,041,700**	**68,100**	**3,355,100**	**59,000**

2.3.4. Highway Mobility Summary

Table 12 presents a summary of highway mobility measures for 2018, 2040 E+C, and 2040 Recommended scenarios. The table shows that in 2040 the recommended corridor projects serve more travelers at a higher speed with less delay. In the Recommended scenario, a typical trip through the corridor can take less than two hours – a 20% reduction in travel time over current speeds. **Figure 2** presents an infographic summary of key highway mobility measures.

Table 12. Highway Mobility Summary

Measure	2018	2040 E+C	2040 Recommended
Length (Miles)	105	105	105
Average Travel Time (Hours)	2.4	2.5	1.9
Vehicle-Miles Traveled	2,398,600	3,041,700	3,355,100
Vehicle-Hours Traveled	50,800	68,100	59,000
Average Annual Daily Volume	22,700	28,800	31,800
Average Speed (Miles per hour)	47	45	57

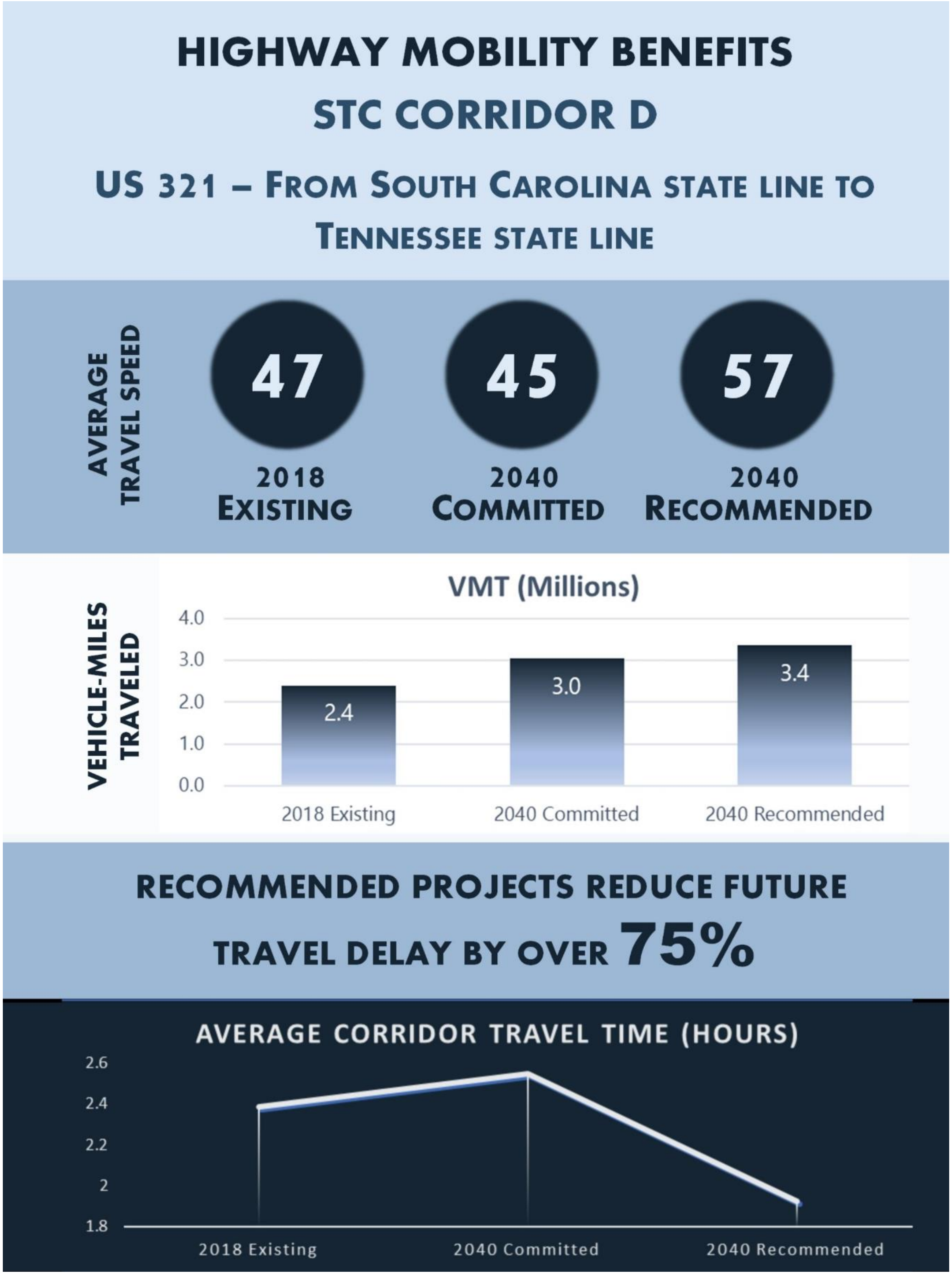

Figure 2. Highway Mobility Summary

3. Freight Mobility

U.S. 321 runs from the Tennessee state line to the South Carolina state line and primarily consists of U.S. 321 and the CSX rail line as shown in **Figure 3**. Freight mobility into, out of, and within U.S. 321 was analyzed using freight flow data downloaded from the North Carolina Freight Flow tool. The freight flow data is presented as volume (tonnage) and value (dollars). It is based on the Federal Highway Administration's (FHWA) Freight Analysis Framework Version 4.1 (FAF4.1) with county-level disaggregation processed by Cambridge Systematics for 2012, 2015, and 2045, and it was forecasted to 2045 using FHWA's FAF4.1 origin-destination and commodity growth rates for rail flows[1].

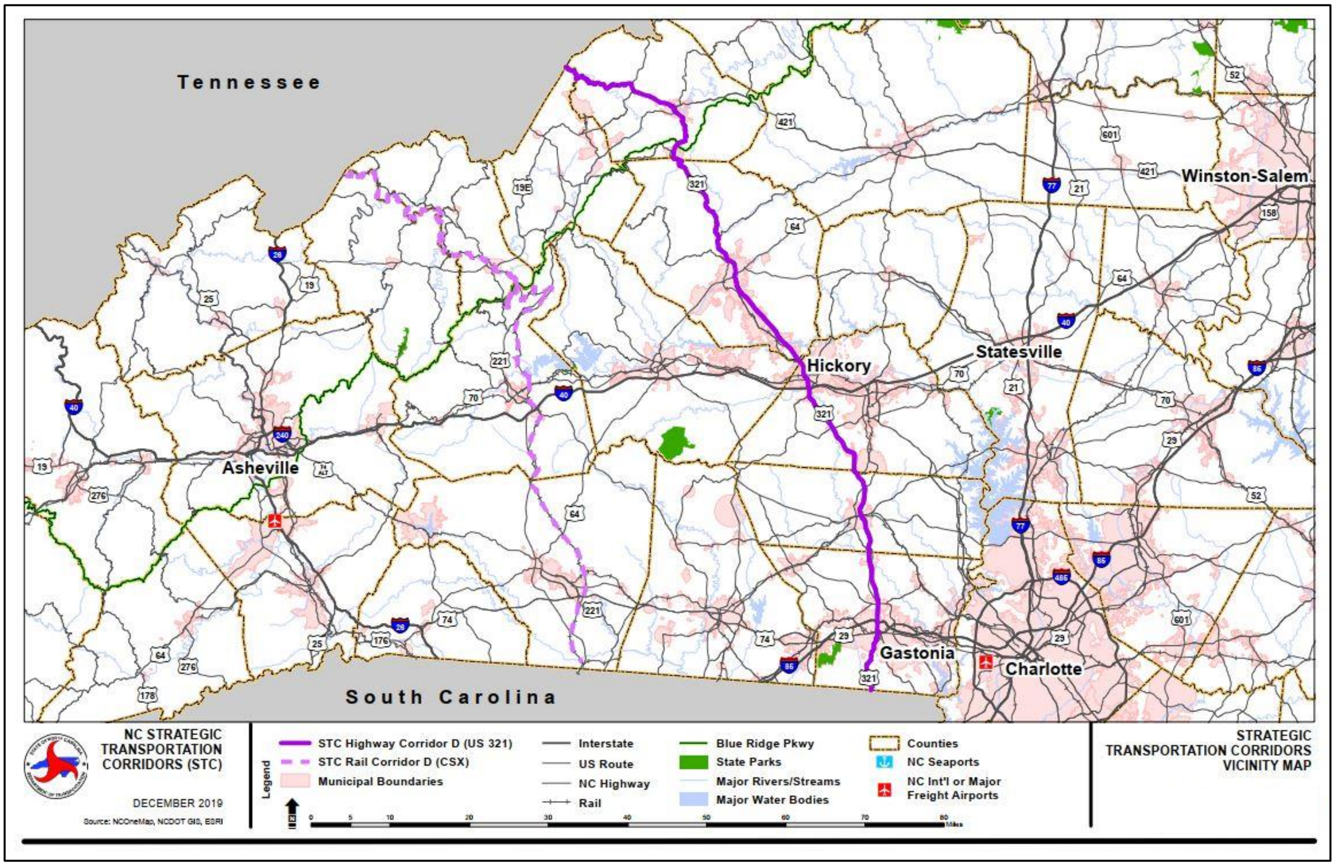

Figure 3. U.S. 321 and CSX line

Freight flow estimates for U.S. 321 include county totals for the 14 counties within the Gastonia, Hickory, Boone, Pisgah, and Southern Foothills regions. The counties included were: Alexander, Avery, Burke, Caldwell, Catawba, Cleveland, Gaston, Lincoln, McDowell, Mitchell, Polk, Rutherford, Watauga, and Yancey. Results are presented for 12 different commodity groups and associated trade partners. Results by trade partners are presented regionally for the United States, at the county level for trade between the corridor and the rest of North Carolina, and at the FAF regional level for all other trade which includes states, large metropolitan areas, the remainder of states with large metropolitan area(s), and international regions for foreign freight flows.

[1] North Carolina Statewide Multimodal Freight Plan, Freight Flow Tool Reference Guide: https://connect.ncdot.gov/projects/planning/Statewide-Freight-Plan/Documents/Freight_Tool_User_Guide.pdf

3.1. Flow Type Totals

Freight flows to, from, and within the U.S. 321 counties (including domestic trade and the domestic leg of foreign trade) totaled an estimated 91.6 million tons worth $103.9 billion in 2015, shown in **Figure 4**. While inbound flows represent half of the corridor's volume, outbound flows account for over half of the value. Flows were forecasted to increase to 117.1 million tons worth $167.3 billion in 2045 (an increase of roughly 28 and 61 percent respectively) with a slight increase in outbound freight to 45 percent of volume and 55 percent of value.

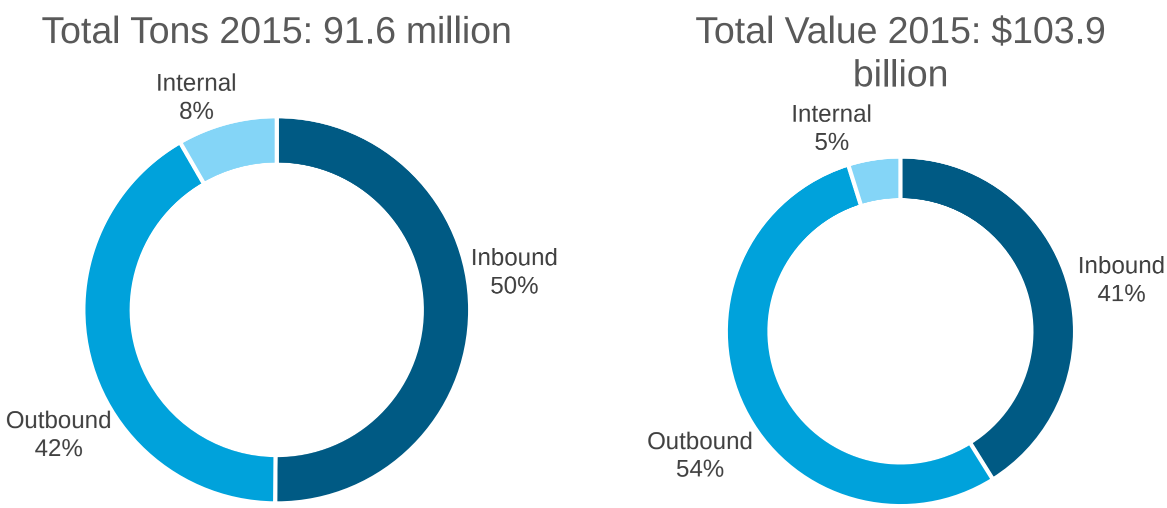

Figure 4. Freight Flow Totals, 2015

3.2. Modal Splits

Trucking dominates the market, moving over 87 percent of the corridor's freight and accounting for almost 95 percent of the total value, shown in **Figure 5**. Carload rail's roughly nine percent of volume translated to one percent of the value in 2015, while pipelines carried almost three percent of the total volume. Air cargo's minimal volume represented three percent of the total value. Modal share forecasts for 2045 show truck volumes increasing to 91 percent with rail carload decreasing to six percent and truck capturing 97 percent of the total flows by value.

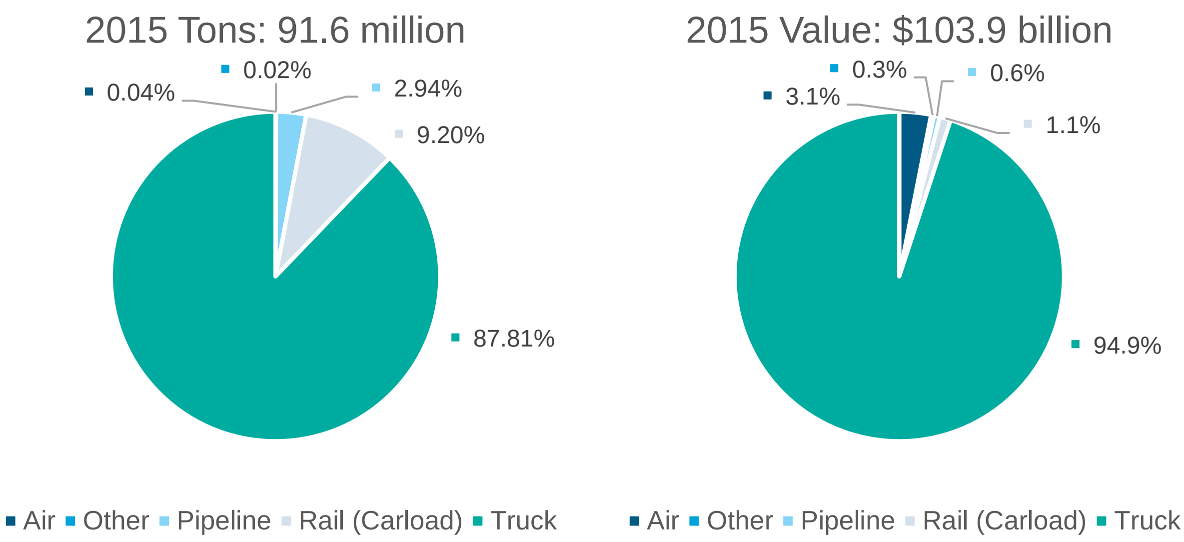

Figure 5. Modal Freight Flow Volume and Value Totals, 2015

3.3. Commodity Comparison, 2015 and 2045

Energy Products (over 18 million tons) accounted for the largest volume of commodities moving to, from, and within the corridor with the majority moving into the region, shown in **Figure 6**. While Aggregates were a close second with just under 18 million tons, forecasts out to 2045 show a nine percent increase in tonnage for Aggregates but over a 30 percent decrease for Energy Products. By 2045, forecasted flow increases of 45 percent in Nonmetallic Mineral and Base Metal Products and 30 percent in Raw and Finished Wood Products equate to almost 18 million tons for both commodity groups. Chemicals, Pharma, Plastics, and Rubber (89 percent), Waste (78 percent), Mixed Freight (65 percent), and Food, Alcohol, and Tobacco (62 percent) are all forecasted to experience significant volume growth.

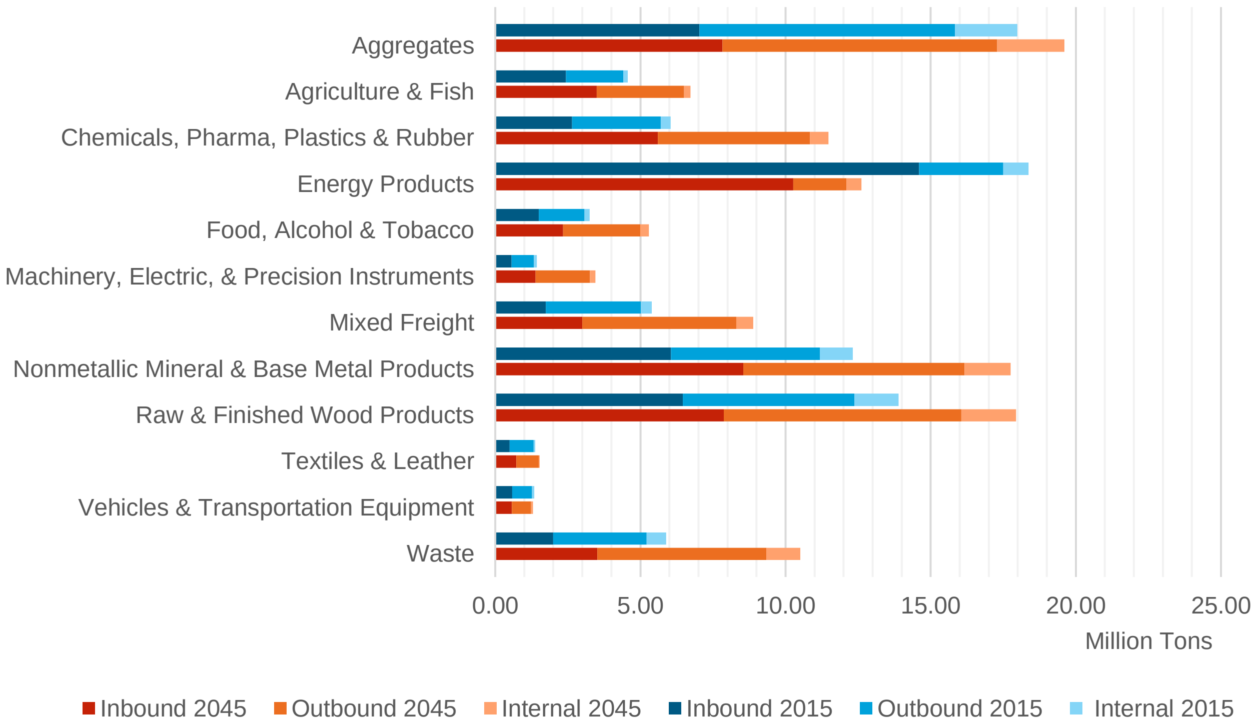

Figure 6. Commodity Volumes, 2015 and 2045

Mixed Freight's almost $24 billion accounted for the largest share of the flows by value in 2015, and its forecasted growth of 63 percent would increase its value to just under $39 billion by 2045. Machinery, Electric, and Precision Instruments are forecasted to experience a 123 percent increase from $17 to $37.8 billion by 2045. Chemicals, Pharmaceuticals, Plastics, and Rubber are expected to almost double in trade by value from $16.7 billion in 2015 to $33 billion in 2045, as shown in **Figure 7**.

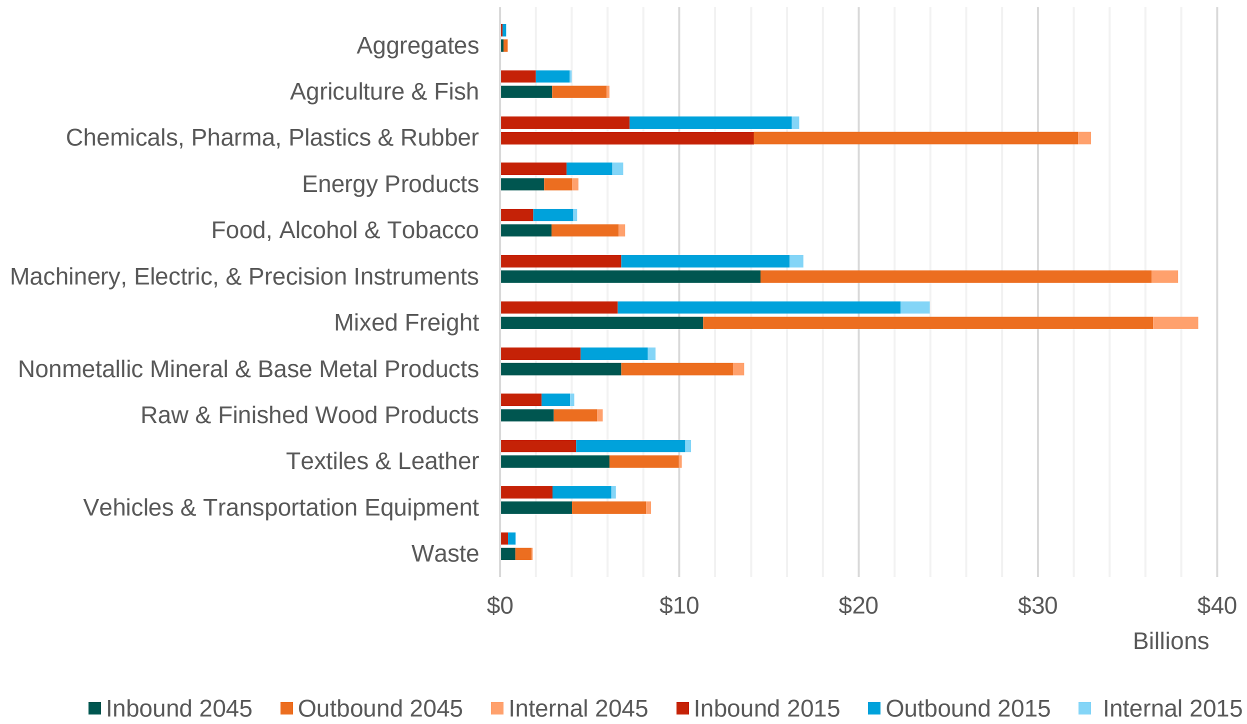

Figure 7. Commodity Values, 2015 and 2045

3.4. Top Trading Partners – by Volume and Value

The counties through which U.S. 321 runs ship and receive the largest volume and value of goods within the Southeast region of the U.S. compared to all other U.S. regions. In 2015, this was estimated to be over 67 million tons valued at over $63 billion and forecasted to grow to over 86 million tons worth almost $100 billion by 2045, shown in **Table 13**. The Mideast region of the U.S. ranked second with just under 11 million tons and $11.5 billion. The counties within the corridor themselves traded 7.6 million tons worth over $5 billion in 2015. The internal tonnage was greater than the total tonnage of the states within the Great Lakes and those west of the Mississippi River combined. Each trading region is visualized in **Figure 8**.

Table 13. Top Regional Trading Partners

Region	Tonnage		Value	
	2015	2045	2015	2045
Internal (North Carolina)	7,639,283	9,495,823	$5,025,031,929	$6,970,970,081
Great Lakes	3,037,973	4,462,078	$8,351,619,665	$13,174,188,449
Mideast	10,995,877	11,523,056	$11,474,542,245	$19,109,941,571
New England/New York	716,206	1,414,571	$4,461,210,824	$7,762,149,025
Southeast	67,085,733	86,421,280	$63,348,073,564	$99,646,118,278
West of the Mississippi	2,151,959	3,809,690	$11,226,621,592	$20,641,317,659
TOTALS	**91,627,031**	**117,126,499**	**103,887,099,819**	**167,304,685,062**

Figure 8. Trading Regions

Mecklenburg County was the top trade partner by volume in 2015, shown in **Figure 9**, with over 11.3 million tons-4.6 million inbound and 6.7 million outbound. Growth in freight volumes with Mecklenburg is forecasted to be over 13.2 million tons by 2045, a roughly 15 percent increase. Trade with New Hanover County is forecasted for the greatest growth from 3 to 5.6 million tons (46 percent). The Other Virginia, Other South Carolina, and West Virginia FAF regions ranked second, third, and fourth, respectively, with roughly 40, 36, and 35 million tons. While the

Other South Carolina region is forecasted for growth in volumes (almost 25 percent to over 47 million tons), trade with the Other Virginia and West Virginia regions is forecasted to decrease by eight and 19 percent respectively.

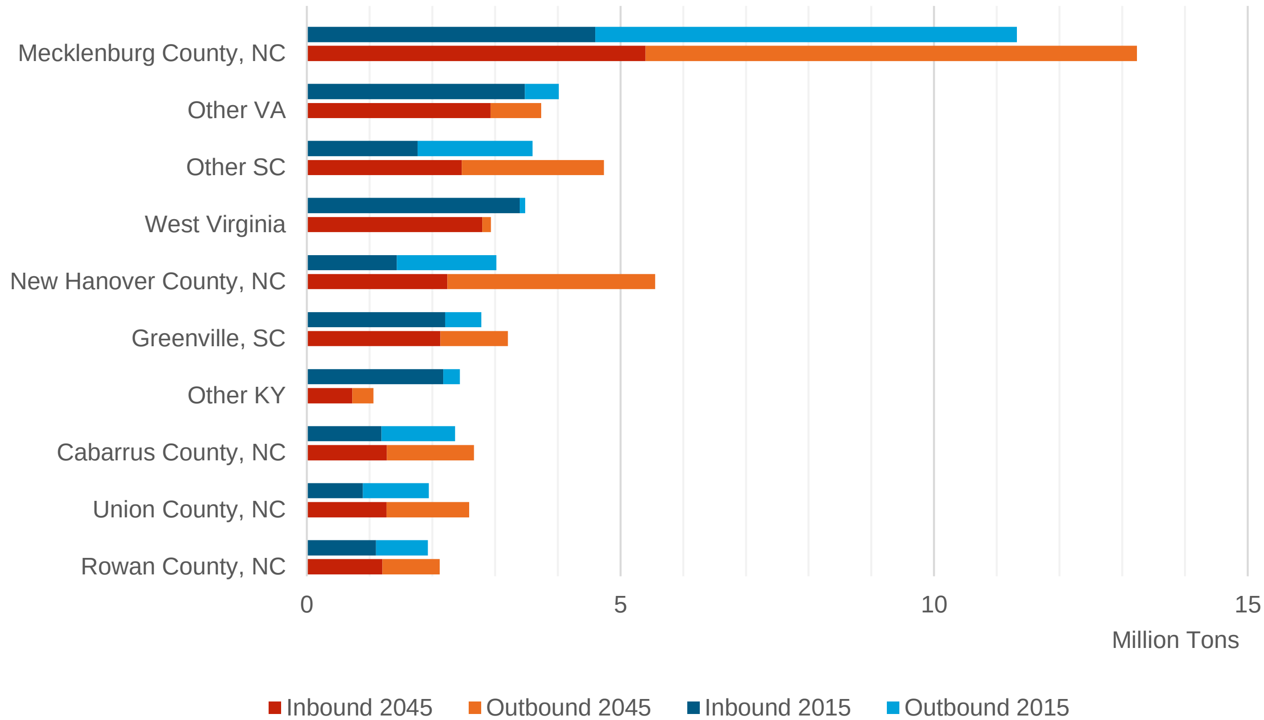

Figure 9. Top Trading Partners by Volume[2]

Trade between the corridor and Mecklenburg County accounted for over $9.5 billion in 2015, making it the region's top trade partner by value as well. By 2045, trade between the two is forecasted to be $15.5 billion (a growth rate of almost 40 percent). Among the other top trade partners, growth by value is forecasted to increase between 25 and 66 percent, shown in **Figure 10**.

[2] "Other" FAF Regions refer to the remainder of a state trading region which does not include separately analyzed metropolitan areas. "Other SC" refers to the remainder of SC not including the Greenville and Charleston metros, "Other VA" refers to the remainder of VA not including the Washington, DC, Virginia Beach, and Richmond metros, and "Other KY" refers to the remainder of KY not including the Cincinnati and Louisville metros.

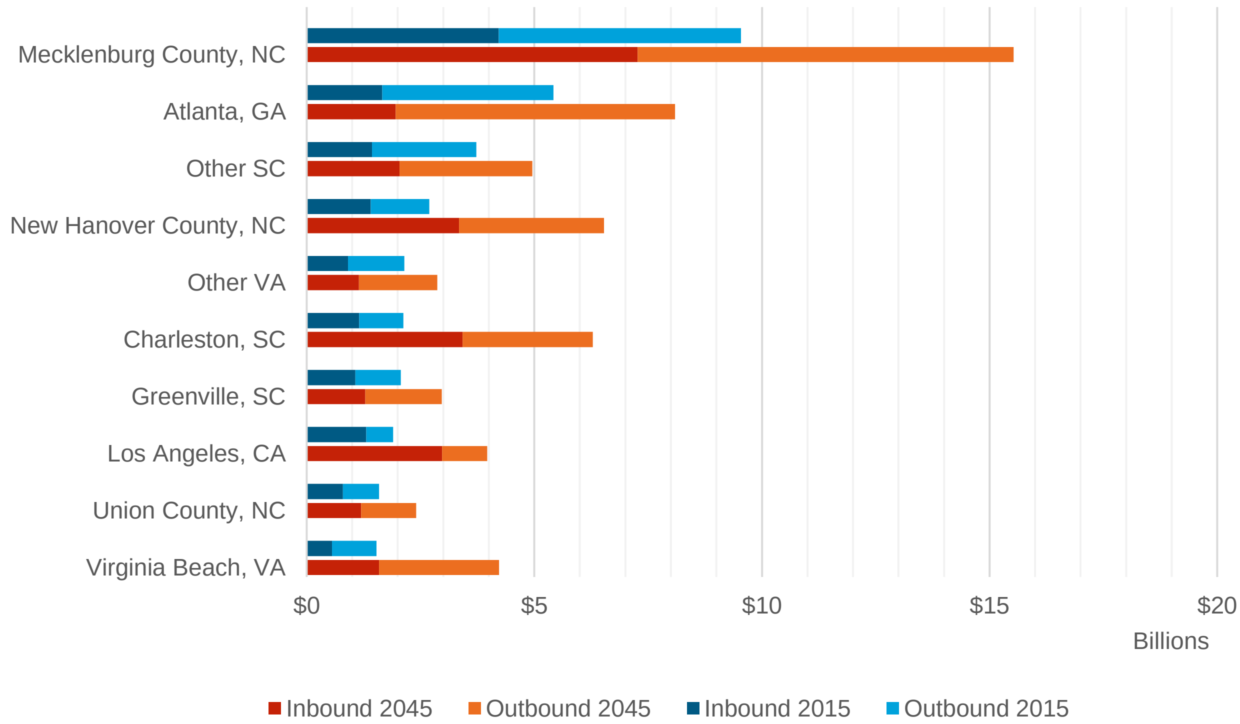

Figure 10. Top Trading Partners by Value, 2015 and 2045

3.5. Foreign Trade

Using 2015 volumes, foreign trade's 2.65 million tons represented 2.9 percent of the total flows, and this is forecasted to more than double to 7.46 million tons (6.4 percent of the total) by 2045. The $12.04 billion worth of foreign trade in 2015 is forecasted to grow to $32.9 billion by 2045. Foreign trade accounted for a higher percentage when comparing by value: 11.6 percent in 2015 and an estimated 19.7 percent in 2045, or $12 billion to $32.9 billion.

Shown in **Figure 11**, tonnage of foreign trade is dominated by water with more than four out of every five tons being moved on the water and trucking ranking second with 14 percent. Shown in **Figure 9**, modal shares of foreign trade by value are more evenly split with water accounting for 49 percent of the total, air 29 percent, and trucking 18 percent.

While little change in modal share by volume is forecasted between 2015 and 2045, significant changes in share by value are expected with water increasing from $5.9 to $20.2 billion (61 percent), trucking increasing from $2.2 to $7.4 billion (22 percent), and air decreasing from $3.5 billion to $3.4 billion (10 percent), as shown in **Figure 12**.

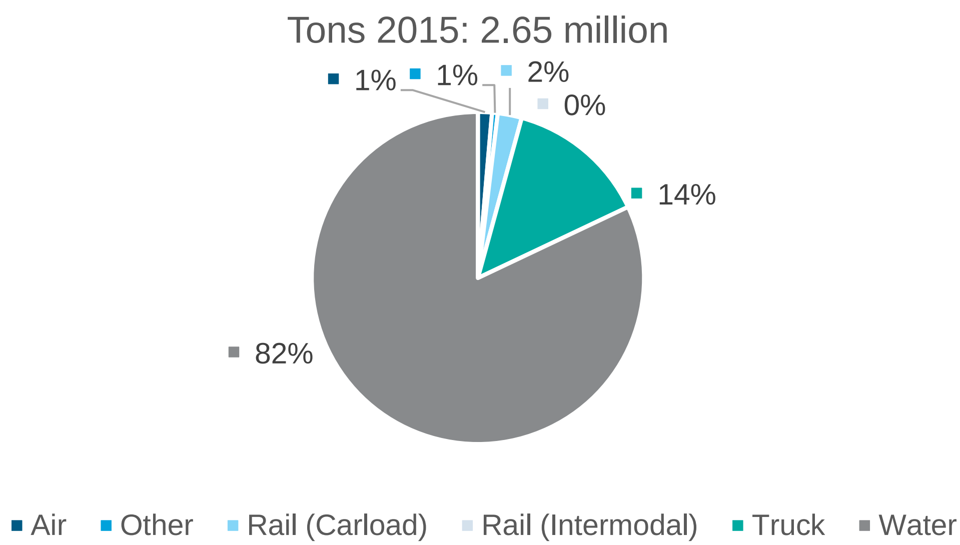

Figure 11. Foreign Trade Freight Flows by Mode and Volume, 2015

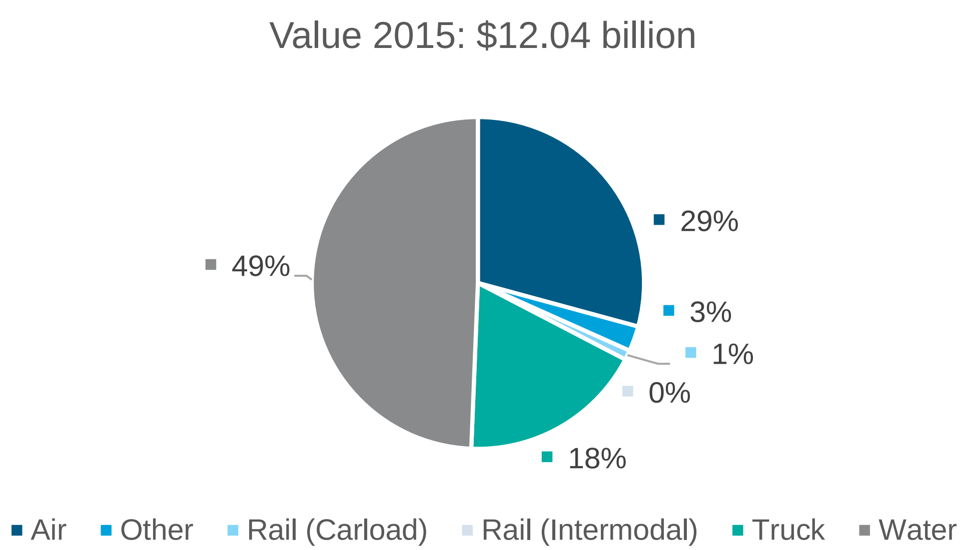

Figure 12. Foreign Trade Freight Flows by Mode and Value, 2015

Chemicals, Pharmaceuticals, Plastics, and Rubber was the top foreign traded commodity group by volume in 2015 with almost 500 thousand tons, and by 2045 is forecasted to increase to just under 1.4 million tons, shown in **Figure 13.** Raw and Finished Wood Products ranked second in 2015 but is forecasted to be the corridor's top trade commodity by volume in 2045 with almost 460 thousand tons and 1.5 million tons, respectively. No other commodity groups are forecasted to have more than 1 million tons by 2045. The almost $4 billion worth of Machinery, Electric, and Precision Instruments in 2015 is forecasted to triple to just under $12 billion by 2045, while the $2.5 billion worth of Chemicals, Pharma, Plastics, and Rubber are forecasted to more than double to $6.5 billion in 2045, shown in **Figure 14**.

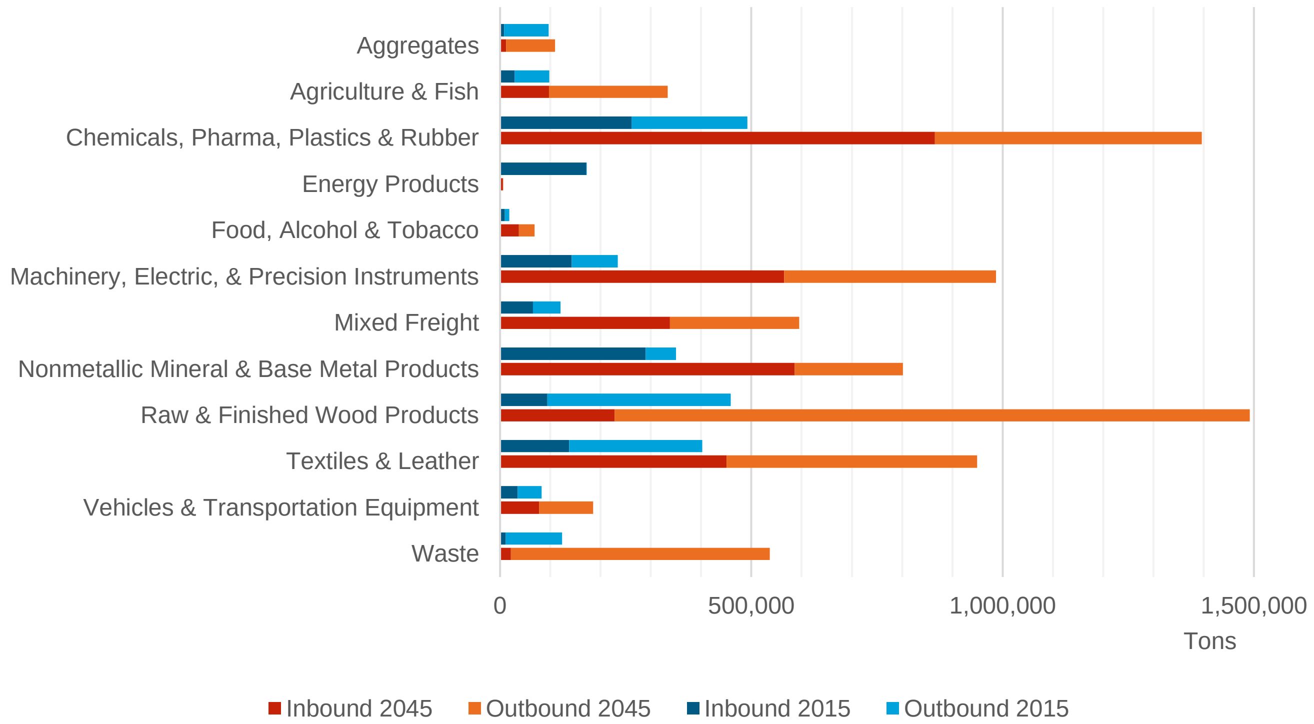

Figure 13. Foreign Trade Commodity Volumes, 2015 and 2045

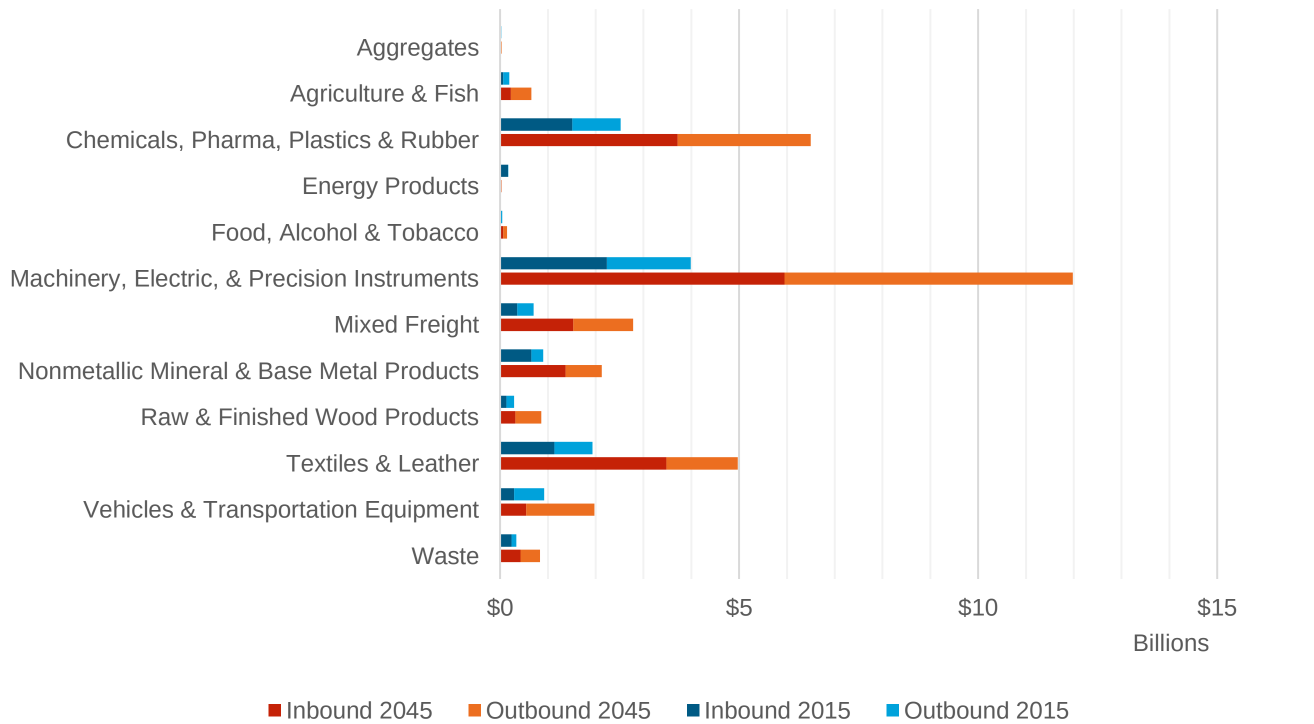

Figure 14. Foreign Trade Commodity Values, 2015 and 2045

In 2015, Eastern Asia was the corridor's top ranked trade partner by volume and accounted for one out of every four tons, shown in **Figure 15**. Its 2045 forecasted volume of 1.35 million tons is almost double that of the 2015 volume. Trade volumes with Europe are also forecasted to almost double from roughly 518 thousand tons in 2015 to over one million tons in 2045. By 2045, trade between U.S. 321 and the Rest of Americas is forecasted to top one million tons as well. In terms of 2015 value, Europe and Eastern Asia accounted for half of the corridor's trade, with Europe's $3.2 billion making it the top trade partner and Eastern Asia's $2.79 billion placing it second. Canada ranked third in 2015 with trade worth $1.5 billion. Trade value with Canada is forecasted to more than triple by 2045, shown in **Figure 16**.

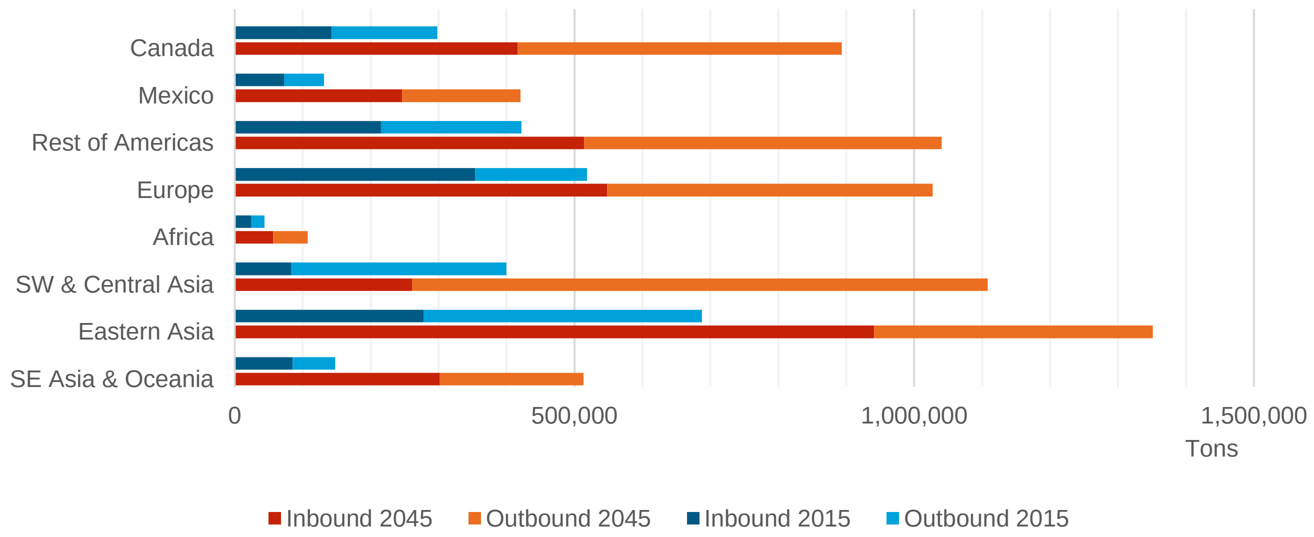

Figure 15. Foreign Trade Partners by Volume, 2015 and 2045

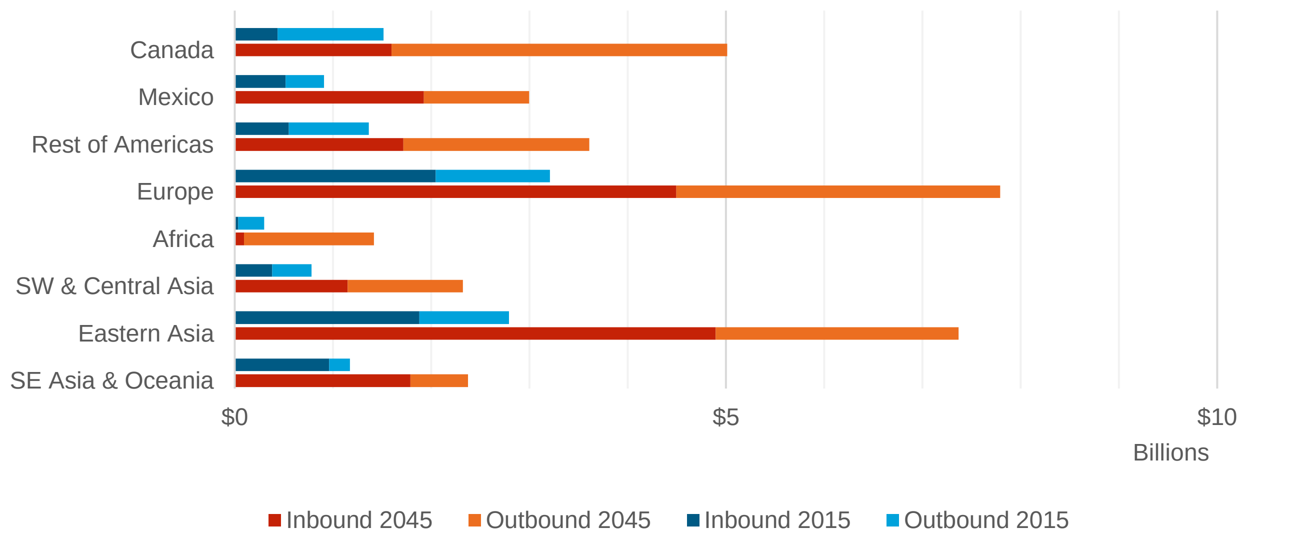

Figure 16. Foreign Trade Partners by Value, 2015 and 2045

Appendices

Appendix A. NCDOT Level of Service D Standards for Systems Level Planning

Level of Service D Standards for Systems Level Planning

Updated 10/14/2011

Level of Service A

Driver Comfort: High

Maximum Density:

12 passenger cars per mile per lane

Level of Service B

Driver Comfort: High

Maximum Density:

20 passenger cars per mile per lane

Level of Service C

Driver Comfort: Some Tension

Maximum Density:

30 passenger cars per mile per lane

Level of Service D

Driver Comfort: Poor

Maximum Density:

42 passenger cars per mile per lane

Level of Service E

Driver Comfort: Extremely Poor

Maximum Density:

67 passenger cars per mile per lane

Level of Service F

Driver Comfort: The lowest

Maximum Density:

More than 67 passenger cars per mile per lane

General Disclaimer

The Level of Service D Standards for Systems Level Planning was derived from the 2005 North Carolina Level of Service (NCLOS) Version 2.1 Program developed by the Institute for Transportation Research and Education (ITRE) at North Carolina State University. The NCLOS Program is based on the 2000 Highway Capacity Manual, published by the Transportation Research Board (TRB).

These standards are intended for **systems level planning only**. Many assumptions are made and documented in the development of these standards.

CTP FACILITY TYPES

FREEWAYS represent a multi-lane divided facility with complete access control (interchanges only and no traffic signals).

EXPRESSWAYS represent a multi-lane divided facility with a high level of access control (interchanges, limited at-grade intersections, right-in/right out access, and no traffic signals).

BOULEVARDS represent a typically divided facility with moderate access control (at-grade intersections, right-in/right out access, and traffic signals at major intersections).

OTHER MAJOR THOROUGHFARES represent undivided facilities with four or more lanes (US and NC routes may have less than 4 lanes). These facilities typically have low access control (at-grade intersections, access to development, and traffic signals at major and some minor intersections).

MINOR THOROUGHFARES represent a 2-to-3 lane undivided facility that is not signed as a US or NC route. These facilities typically have low access control (at-grade intersections, access to development, and traffic signals at major and minor intersections).

NCLOS (HCM) FACILITY TYPES

FREEWAYS (Freeways) represent a multi-lane divided facility with complete access control (interchanges only and no traffic signals).

EXPRESSWAYS (Multi-lane Highways) represent a multi-lane divided facility with a high level of access control (interchanges, limited at-grade intersections, right-in/right out access, and no traffic signals).

BOULEVARDS (Arterials, 25-55 MPH) represent a typically divided facility with moderate access control (at-grade intersections, right-in/right out access, and traffic signals at major intersections).

OTHER MAJOR THOROUGHFARES (Arterials, 25-55 MPH) represent undivided facilities with four or more lanes (US and NC routes may have less than 4 lanes). These facilities typically have low access control (at-grade intersections, access to development, and traffic signals at major and some minor intersections). These facilities are typically within an urban or suburban area (e.g. within a municipality or ETJ).

MINOR THOROUGHFARES (Arterials 25-55 MPH) represent a 2-to-3 lane undivided facility that is not signed as a US or NC route. These facilities typically have low access control (at-grade intersections, access to development, and traffic signals at major and minor intersections). These facilities are typically within an urban or suburban area (e.g. within a municipality or ETJ).

RURAL 2-LANE HIGHWAY (Two-Lane Highway, 55 MPH ONLY) represents a 2-lane undivided facility outside of a municipality or ETJ. These facilities have a 55 MPH posted speed limit, have low access control with numerous driveways and no traffic signals. These facilities are classified in a CTP as **other major thoroughfares** if they are a **US or NC route** or **minor thoroughfares** if they are a **secondary or local** route.

AREA TYPE

RURAL represents an area outside a municipality or Extraterritorial Jurisdiction (ETJ).

SUBURBAN represents an area within a municipality or ETJ that is not within a Central Business District (CBD) or areas immediately surrounding a CBD.

URBAN represents an area that is within a CBD or areas immediately surrounding a CBD.

LEVEL OF SERVICE D VALUES

MINIMUM CAPACITY VALUES represents conditions/inputs that result in a worst-case Level of Service D for a given facility. This lower value represents worst-case conditions in available data for a given region (Higher K/D Factors, Lower Peak Hour Factor, poor road conditions, etc.).

STANDARD CAPACITY VALUES represents an average Level of Service D for a given facility. This default value is an average of available data for a given region.

MAXIMUM CAPACITY VALUES represents conditions/inputs that result in a best-case Level of Service D for a given facility. This higher value represents best-case conditions in available data for a given region (Lower K/D Factors, Higher Peak Hour Factor, etc.).

These assumptions may not pertain to all systems level planning work; therefore, separate analysis may need to be conducted on a case-by-case basis.

These standards are **not** intended for project specific or corridor analysis. Separate analysis would be required for these types of projects.

Volumes shown represent the point at which traffic transitions from LOS D to LOS E.

Level of Service D Standards for Freeways *

COASTAL	2 Lanes Per Direction			3 Lanes Per Direction			4 Lanes Per Direction		
	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
0-5% Trucks	**67400**	**66900**	**67900**	**102000**	**101300**	**101800**	**137300**	**136200**	**135700**
6-10% Trucks	**65700**	**65400**	**66200**	**99600**	**98900**	**99400**	**134000**	**133000**	**132500**
11-15% Trucks	**64200**	**63800**	**64700**	**97300**	**96600**	**97100**	**130900**	**129900**	**129400**
16-20% Trucks	**62800**	**62400**	**63200**	**95100**	**94400**	**94900**	**127900**	**126900**	**126500**
21-25% Trucks	**61400**	**61000**	**61800**	**9300**	**92300**	**92700**	**125100**	**124100**	**123700**
26-30% Trucks	**60000**	**59700**	**60500**	**90900**	**90300**	**90700**	**122400**	**121400**	**121000**
31-35% Trucks	**58800**	**58400**	**59200**	**89000**	**88400**	**88800**	**119800**	**118800**	**118400**

PIEDMONT	2 Lanes Per Direction			3 Lanes Per Direction			4 Lanes Per Direction		
	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
0-5% Trucks	**61700**	**61400**	**62200**	**93500**	**92900**	**93300**	**125800**	**124900**	**124400**
6-10% Trucks	**60300**	**59900**	**60700**	**91300**	**90700**	**91100**	**122800**	**121900**	**121500**
11-15% Trucks	**58900**	**58500**	**59300**	**89200**	**88600**	**89000**	**120000**	**119100**	**118600**
16-20% Trucks	**57500**	**57200**	**58000**	**87100**	**86500**	**87000**	**117300**	**116400**	**115900**
21-25% Trucks	**56300**	**55900**	**56700**	**85200**	**84600**	**85000**	**114700**	**113800**	**113400**
26-30% Trucks	**55000**	**54700**	**55400**	**83400**	**82800**	**83200**	**112200**	**111300**	**110900**
31-35% Trucks	**53900**	**53500**	**54300**	**81600**	**81000**	**81400**	**109800**	**108900**	**108500**

MOUNTAIN	2 Lanes Per Direction			3 Lanes Per Direction			4 Lanes Per Direction		
(Level Terrain)	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
0-5% Trucks	**56100**	**61400**	**62200**	**85000**	**92900**	**93300**	**114400**	**124900**	**124400**
6-10% Trucks	**54800**	**59900**	**60700**	**83000**	**90700**	**91100**	**111700**	**121900**	**121500**
11-15% Trucks	**53500**	**58500**	**59300**	**81100**	**88600**	**89000**	**109100**	**119100**	**118600**
16-20% Trucks	**52300**	**57200**	**58000**	**79200**	**86500**	**87000**	**106600**	**116400**	**115900**
21-25% Trucks	**51100**	**55900**	**56700**	**77500**	**84600**	**85000**	**104200**	**113800**	**113400**
26-30% Trucks	**50000**	**54700**	**55400**	**75800**	**82800**	**83200**	**102000**	**111300**	**110900**
31-35% Trucks	**49000**	**53500**	**54300**	**74200**	**81000**	**81400**	**99800**	**108900**	**108500**

MOUNTAIN	2 Lanes Per Direction			3 Lanes Per Direction			4 Lanes Per Direction		
(Rolling Terrian)	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
0-5% Trucks	**53500**	**58500**	**59300**	**81100**	**88600**	**89000**	**109100**	**119100**	**118600**
6-10% Trucks	**50000**	**54700**	**55400**	**75800**	**82800**	**83200**	**102000**	**111300**	**110900**
11-15% Trucks	**47000**	**51400**	**52100**	**71100**	**77700**	**78100**	**95700**	**104500**	**104100**
16-20% Trucks	**44300**	**48400**	**49000**	**67000**	**73200**	**73600**	**90200**	**98500**	**98100**
21-25% Trucks	**41800**	**45700**	**46400**	**63400**	**69200**	**69600**	**85300**	**93100**	**92700**
26-30% Trucks	**39700**	**43400**	**44000**	**60100**	**65700**	**66000**	**80900**	**88300**	**87900**
31-35% Trucks	**37700**	**41200**	**41800**	**57100**	**62400**	**62700**	**76900**	**83900**	**83600**

Uses "Freeways" Facility Type in NCLOS
*** Assumes Regional K and D Factor Averages**

See Appendix A1 for HCM 2000 Freeway Equations
Use Appendix A2: Coastal Freeway Inputs for adjustments
Use Appendix A3: Piedmont Freeway Inputs for adjustments
Use Appendix A4: Mountain (Level) Freeway Inputs for adjustments
Use Appendix A5: Mountain (Rolling) Freeway Inputs for adjustments

NOTE: Truck percentage occurs within the peak hour, not a daily truck percentage

Level of Service D Standards for Expressways *

COASTAL	2 Lanes Per Direction			3 Lanes Per Direction			4 Lanes Per Direction		
	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
0-5% Trucks	**47500**	**58500**	**58800**	**71200**	**87700**	**88300**	**95000**	**117000**	**117700**
6-10% Trucks	**46400**	**57100**	**57400**	**69500**	**85600**	**86200**	**92700**	**114200**	**114900**
11-15% Trucks	**45300**	**55800**	**56100**	**67900**	**83700**	**84200**	**90600**	**111500**	**112200**
16-20% Trucks	**44200**	**54500**	**54800**	**66400**	**81800**	**82200**	**88500**	**109000**	**109700**
21-25% Trucks	**43300**	**53300**	**53600**	**64900**	**79900**	**80400**	**86500**	**106600**	**107200**
26-30% Trucks	**42300**	**52100**	**52400**	**63500**	**78200**	**78700**	**84700**	**104300**	**104900**
31-35% Trucks	**41400**	**51000**	**51300**	**62100**	**76500**	**77000**	**82900**	**102100**	**102700**

PIEDMONT	2 Lanes Per Direction			3 Lanes Per Direction			4 Lanes Per Direction		
	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
0-5% Trucks	**47500**	**58500**	**58800**	**71200**	**87700**	**88300**	**95000**	**117000**	**117700**
6-10% Trucks	**46400**	**57100**	**57400**	**69500**	**85600**	**86200**	**92700**	**114200**	**114900**
11-15% Trucks	**45300**	**55800**	**56100**	**67900**	**83700**	**84200**	**90600**	**111500**	**112200**
16-20% Trucks	**44200**	**54500**	**54800**	**66400**	**81800**	**82200**	**88500**	**109000**	**109700**
21-25% Trucks	**43300**	**53300**	**53600**	**64900**	**79900**	**80400**	**86500**	**106600**	**107200**
26-30% Trucks	**42300**	**52100**	**52400**	**63500**	**78200**	**78700**	**84700**	**104300**	**104900**
31-35% Trucks	**41400**	**51000**	**51300**	**62100**	**76500**	**77000**	**82900**	**102100**	**102700**

MOUNTAIN	2 Lanes Per Direction			3 Lanes Per Direction			4 Lanes Per Direction		
(Level Terrain)	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
0-5% Trucks	**47500**	**53200**	**58800**	**71200**	**79800**	**88300**	**95000**	**106400**	**117700**
6-10% Trucks	**46400**	**51900**	**57400**	**69500**	**77900**	**86200**	**92700**	**103800**	**114900**
11-15% Trucks	**45300**	**50700**	**56100**	**67900**	**76100**	**84200**	**90600**	**101400**	**112200**
16-20% Trucks	**44200**	**49500**	**54800**	**66400**	**74300**	**82200**	**88500**	**99100**	**109700**
21-25% Trucks	**43300**	**48400**	**53600**	**64900**	**72700**	**80400**	**86500**	**96900**	**107200**
26-30% Trucks	**42300**	**47400**	**52400**	**63500**	**71100**	**78700**	**84700**	**94800**	**104900**
31-35% Trucks	**41400**	**46400**	**51300**	**62100**	**69600**	**77000**	**82900**	**92800**	**102700**

MOUNTAIN	2 Lanes Per Direction			3 Lanes Per Direction			4 Lanes Per Direction		
(Rolling Terrian)	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
0-5% Trucks	**41200**	**50700**	**56100**	**61700**	**76100**	**84200**	**82300**	**101400**	**112200**
6-10% Trucks	**38500**	**47400**	**52400**	**57700**	**71100**	**78700**	**77000**	**94800**	**110400**
11-15% Trucks	**36100**	**44500**	**49200**	**54200**	**66700**	**73900**	**72200**	**89000**	**98500**
16-20% Trucks	**34000**	**41900**	**46400**	**51100**	**62900**	**69600**	**68100**	**83900**	**92800**
21-25% Trucks	**32200**	**39600**	**43900**	**48300**	**59500**	**65800**	**64400**	**79300**	**87700**
26-30% Trucks	**30500**	**37600**	**41600**	**45800**	**56400**	**62400**	**61000**	**75200**	**83200**
31-35% Trucks	**29000**	**35700**	**39600**	**43500**	**53600**	**59300**	**58000**	**71500**	**79100**

Uses "Multi-lane Highways" Facility Type in NCLOS
*** Assumes Regional K and D Factor Averages**

See Appendix B1 for HCM 2000 Multi-lane Highway Equations
Use Appendix B2: Coastal Expressway Inputs for adjustments
Use Appendix B3: Piedmont Expressway Inputs for adjustments
Use Appendix B4: Mountain (Level) Expressway Inputs for adjustments
Use Appendix B5: Mountain (Rolling) Expressway Inputs for adjustments

NOTE: Truck percentage occurs within the peak hour, not a daily truck percentage

Level of Service D Standards for Boulevards *

COASTAL	1 Lane Per Direction				2 Lanes Per Direction				3 Lanes Per Direction		
	Urban	Suburban	Rural		Urban	Suburban	Rural		Urban	Suburban	Rural
55 MPH	**21600**	**21900**	**24500**		**43300**	**43900**	**49000**		**64900**	**65800**	**73500**
45 MPH	**18900**	**19800**	**23600**		**38100**	**39700**	**47200**		**57200**	**59600**	**70800**
35 MPH	**14000**	**16900**			**28100**	**34300**			**42200**	**51700**	
25 MPH	**12500**				**25400**				**38400**		

PIEDMONT	1 Lane Per Direction				2 Lanes Per Direction				3 Lanes Per Direction		
	Urban	Suburban	Rural		Urban	Suburban	Rural		Urban	Suburban	Rural
55 MPH	**19900**	**20200**	**22600**		**40000**	**40500**	**45200**		**59900**	**60700**	**67900**
45 MPH	**17500**	**18300**	**21800**		**35100**	**36600**	**43600**		**52800**	**55000**	**65400**
35 MPH	**14000**	**15600**			**28100**	**31600**			**42200**	**47700**	
25 MPH	**12500**				**25400**				**38400**		

MOUNTAIN	1 Lane Per Direction				2 Lanes Per Direction				3 Lanes Per Direction		
	Urban	Suburban	Rural		Urban	Suburban	Rural		Urban	Suburban	Rural
55 MPH	**21600**	**21900**	**22300**		**43300**	**43900**	**44500**		**64900**	**65800**	**66800**
45 MPH	**18900**	**20700**	**21400**		**38100**	**41400**	**42900**		**57200**	**62100**	**64400**
35 MPH	**14000**	**18500**			**28100**	**37400**			**42200**	**56400**	
25 MPH	**12500**				**25400**				**38400**		

Uses "Principal Arterials" Facility Type in NCLOS
*** Assumes Regional K and D Factor Averages**

See Appendix C1 for HCM Urban Arterial Equations
Use Appendix C2: Coastal Boulevard Inputs for adjustments
Use Appendix C3: Piedmont Boulevard Inputs for adjustments
Use Appendix C4: Mountain Boulevard Inputs for adjustments

NOTE: Inputs assume 12-foot lanes. To adjust lane-width downward, subtract 3.33% per foot of pavement and round to the nearest hundred

Coastal Level of Service D Standards
for Other Major Thoroughfares *

55 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	15100	15800	16400		16600	17200	17800
11 foot lanes	14600	15300	15900		16100	16600	17200
10 foot lanes	14100	14700	15300		15500	16100	16600
9 foot lanes	13600	14200	14800		15000	15500	16000
45 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	13200	13800	14600		14500	14900	16000
11 foot lanes	12800	13300	14100		14000	14400	15500
10 foot lanes	12300	12900	13600		13500	13900	15000
9 foot lanes	11900	12420	13140		13050	13400	14400
35 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	11100	12600			12700	14000	
11 foot lanes	10700	12200			12300	13500	
10 foot lanes	10400	11800			11900	13100	
9 foot lanes	10000	11300			11400	12600	
25 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	11000				12700		
11 foot lanes	10600				12300		
10 foot lanes	10300				11900		
9 foot lanes	9900				11400		

Uses "Principal Arterials" Facility Type in NCLOS

*** Decrease in Lane Width Capacity calculated via 2000 Highway Capacity Manual lane-width adjustment factor for saturation flow rate**

See Appendix D1 for HCM 2000 Urban Arterial Equations
Use Appendix D2: Coastal Major Thoroughfare Inputs for adjustments

NOTE: Lane Width is adjusted downward by 3.33% per less foot of pavement and rounded to the nearest hundred

Coastal Level of Service D Standards for Other Major Thoroughfares *

55 MPH	2 Lanes Per Direction				2 Lanes Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	30400	31600	32800		33300	34500	35700
11 foot lanes	29400	30600	31700		32200	33400	34500
10 foot lanes	29400	29500	30600		31100	32200	33300
9 foot lanes	27400	28400	29500		30000	31100	32100
45 MPH	2 Lanes Per Direction				2 Lanes Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	26700	27600	29300		29000	29900	32000
11 foot lanes	25900	26700	28300		28000	28900	30900
10 foot lanes	25000	25800	27300		27100	27900	29900
9 foot lanes	24000	24800	26400		26100	26900	29000
35 MPH	2 Lanes Per Direction				2 Lanes Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	22200	25500			24300	28100	
11 foot lanes	21500	24700			23500	27200	
10 foot lanes	20700	23800			22700	26200	
9 foot lanes	20000	23000			21900	25300	
25 MPH	2 Lanes Per Direction				2 Lanes Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	22100				24200		
11 foot lanes	21400				23400		
10 foot lanes	20500				22600		
9 foot lanes	19900				21800		

Uses "Principal Arterials" Facility Type in NCLOS

*** Decrease in Lane Width Capacity calculated via 2000 Highway Capacity Manual lane-width adjustment factor for saturation flow rate**

See Appendix D1 for HCM 2000 Urban Arterial Equations
Use Appendix D2: Coastal Major Thoroughfare Inputs for adjustments

NOTE: Lane Width is adjusted downward by 3.33% per less foot of pavement and rounded to the nearest hundred

Piedmont Level of Service D Standards for Other Major Thoroughfares *

55 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	12900	14600	15100		14200	15900	16500
11 foot lanes	12500	14100	14600		13700	15400	16000
10 foot lanes	12000	13600	14100		13300	14800	15400
9 foot lanes	11600	13100	13600		12800	14300	14900
45 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	12200	12700	14600		13300	13800	16000
11 foot lanes	11800	12300	14100		12900	13300	15500
10 foot lanes	11400	11900	13600		12400	12900	14900
9 foot lanes	11000	11400	13100		12000	12400	14400
35 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	11100	11600			12700	12900	
11 foot lanes	10700	11200			12300	12500	
10 foot lanes	10400	10800			11900	12000	
9 foot lanes	10000	10400			11400	11600	
25 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	11000				12700		
11 foot lanes	10600				12300		
10 foot lanes	10300				11900		
9 foot lanes	9900				11400		

Uses "Principal Arterials" Facility Type in NCLOS

*** Decrease in Lane Width Capacity calculated via 2000 Highway Capacity Manual lane-width adjustment factor for saturation flow rate**

See Appendix D1 for HCM 2000 Urban Arterial Equations
Use Appendix D3: Piedmont Major Thoroughfare Inputs for adjustments

NOTE: Lane Width is adjusted downward by 3.33% per less foot of pavement

Piedmont Level of Service D Standards for Other Major Thoroughfares *

55 MPH	2 Lanes Per Direction				2 Lanes Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	25800	29100	30200		28400	31800	33000
11 foot lanes	24900	28100	29200		27500	30800	31900
10 foot lanes	24100	27200	28200		26500	29700	30800
9 foot lanes	23200	26200	27200		25600	28600	29700
45 MPH	2 Lanes Per Direction				2 Lanes Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	24600	25500	29300		26800	27600	32000
11 foot lanes	23800	24700	28300		25900	26700	31000
10 foot lanes	23000	23800	27300		25000	25800	29900
9 foot lanes	22100	23000	26400		24100	24800	28800
35 MPH	2 Lanes Per Direction				2 Lanes Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	22200	23500			24300	26000	
11 foot lanes	21500	22700			23500	25100	
10 foot lanes	20700	21900			22700	24300	
9 foot lanes	20000	21200			21900	23400	
25 MPH	2 Lanes Per Direction				2 Lanes Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	22100				24200		
11 foot lanes	21400				23400		
10 foot lanes	20600				22600		
9 foot lanes	19900				21800		

Uses "Principal Arterials" Facility Type in NCLOS

*** Decrease in Lane Width Capacity calculated via 2000 Highway Capacity Manual lane-width adjustment factor for saturation flow rate**

See Appendix D1 for HCM 2000 Urban Arterial Equations
Use Appendix D3: Piedmont Major Thoroughfare Inputs for adjustments

NOTE: Lane Width is adjusted downward by 3.33% per less foot of pavement and rounded to the nearest hundred

Mountain Level of Service D Standards for Other Major Thoroughfares *

55 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	14000	14600	15100		15300	15900	16500
11 foot lanes	13500	14100	14600		14800	15400	16000
10 foot lanes	13100	13600	14100		14300	14800	15400
9 foot lanes	12600	13100	13600		13800	14300	14900
45 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	12200	12700	14600		13300	13800	16000
11 foot lanes	11800	12300	14100		12900	13300	15500
10 foot lanes	11400	11900	13600		12400	12900	14900
9 foot lanes	11000	11400	13100		12000	12400	14400
35 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	11000	11600			12700	12900	
11 foot lanes	10600	11200			12300	12500	
10 foot lanes	10300	10800			11900	12000	
9 foot lanes	9900	10400			11400	11600	
25 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	11000				12700		
11 foot lanes	10600				12300		
10 foot lanes	10300				11900		
9 foot lanes	9900				11400		

Uses "Principal Arterials" Facility Type in NCLOS

*** Decrease in Lane Width Capacity calculated via 2000 Highway Capacity Manual lane-width adjustment factor for saturation flow rate**

See Appendix D1 for HCM 2000 Urban Arterial Equations
Use Appendix D4: Mountains Major Thoroughfare Inputs for adjustments

NOTE: Lane Width is adjusted downward by 3.33% per less foot of pavement and rounded to the nearest hundred

Mountain Level of Service D Standards
for Other Major Thoroughfares *

55 MPH	2 Lanes Per Direction				2 Lanes Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	28000	29100	30200		30800	31800	33000
11 foot lanes	27100	28100	29200		29800	30800	31900
10 foot lanes	26100	27200	28200		28700	29700	30800
9 foot lanes	25200	26200	27200		27700	28600	29700
45 MPH	2 Lanes Per Direction				2 Lanes Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	24600	25500	29300		26800	27600	32000
11 foot lanes	23800	24700	28300		25900	26700	30900
10 foot lanes	23000	23800	27300		25000	25800	29900
9 foot lanes	22100	23000	26400		24100	24800	28800
35 MPH	2 Lanes Per Direction				2 Lanes Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	22200	23500			24300	26000	
11 foot lanes	21500	22700			23500	25400	
10 foot lanes	20700	21900			22700	24300	
9 foot lanes	20000	21200			21900	23400	
25 MPH	2 Lanes Per Direction				2 Lanes Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	22100				24200		
11 foot lanes	21400				23400		
10 foot lanes	20600				22600		
9 foot lanes	19900				21800		

Uses "Principal Arterials" Facility Type in NCLOS

*** Decrease in Lane Width Capacity calculated via 2000 Highway Capacity Manual lane-width adjustment factor for saturation flow rate**

See Appendix D1 for HCM 2000 Urban Arterial Equations
Use Appendix D4: Mountains Major Thoroughfare Inputs for adjustments

NOTE: Lane Width is adjusted downward by 3.33% per less foot of pavement

Coastal Level of Service D Standards for Minor Thoroughfares *

55 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	15100	15800	16400		16600	17200	17800
11 foot lanes	14600	15300	15900		16100	16600	17200
10 foot lanes	14100	14700	15300		15500	16100	16600
9 foot lanes	13600	14200	14800		14900	15500	16000

45 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	12700	13300	14600		14200	14300	16000
11 foot lanes	12300	12900	14100		13700	13800	15500
10 foot lanes	11900	12400	13600		13300	13300	14900
9 foot lanes	11400	12000	13100		12800	12900	14400

35 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	10500	11000			11500	13700	
11 foot lanes	10200	10600			11100	13300	
10 foot lanes	9800	10300			10700	12800	
9 foot lanes	9500	9900			10400	12300	

25 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	10000				11300		
11 foot lanes	9700				10900		
10 foot lanes	9300				10500		
9 foot lanes	9000				10200		

Uses "Principal Arterials" and "Minor Arterials" Facility Types in NCLOS

*** Decrease in Lane Width Capacity calculated via 2000 Highway Capacity Manual lane-width adjustment factor for saturation flow rate**

See Appendix E1 for HCM 2000 Urban Arterial Equations
Use Appendix E2: Coastal Minor Thoroughfare Inputs for adjustments

NOTE: Lane Width is adjusted downward by 3.33% per less foot of pavement

Piedmont Level of Service D Standards
for Minor Thoroughfares *

55 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	12900	14600	15100		14200	15900	16500
11 foot lanes	12500	14100	14600		13700	15400	16000
10 foot lanes	12000	13600	14100		13300	14800	15400
9 foot lanes	11600	13100	13600		12800	14300	14900

45 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	11700	12200	14600		13100	13200	16000
11 foot lanes	11300	11800	14100		12700	12800	15500
10 foot lanes	10900	11400	13600		12200	12300	14900
9 foot lanes	10500	11000	13100		11800	11900	14400

35 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	10200	10200			11700	12700	
11 foot lanes	9900	9900			11300	12300	
10 foot lanes	9500	9500			10900	11900	
9 foot lanes	9200	9200			10500	11400	

25 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	10000				11300		
11 foot lanes	9700				10900		
10 foot lanes	9300				10500		
9 foot lanes	9000				10200		

Uses "Principal Arterials" and "Minor Arterials" Facility Types in NCLOS

*** Decrease in Lane Width Capacity calculated via 2000 Highway Capacity Manual lane-width adjustment factor for saturation flow rate**

See Appendix E1 for HCM 2000 Urban Arterial Equations
Use Appendix E3: Piedmont Minor Thoroughfare Inputs for adjustments

NOTE: Lane Width is adjusted downward by 3.33% per less foot of pavement

Mountain Level of Service D Standards for Minor Thoroughfares *

55 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	14000	14600	15100		15300	15900	16500
11 foot lanes	13500	14100	14600		14800	15400	16000
10 foot lanes	13100	13600	14100		14300	14800	15400
9 foot lanes	12600	13100	13600		13800	14300	14900

45 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	11700	12200	14600		13100	13200	16000
11 foot lanes	11300	11800	14100		12700	12800	15500
10 foot lanes	10900	11400	13600		12200	12300	14900
9 foot lanes	10500	11000	13100		11800	11900	14400

35 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	10200	10200			11500	12700	
11 foot lanes	9900	9900			11100	12300	
10 foot lanes	9500	9500			10700	11900	
9 foot lanes	9200	9200			10400	11400	

25 MPH	1 Lane Per Direction				1 Lane Per Direction WCLTL		
	Urban	Suburban	Rural		Urban	Suburban	Rural
12 foot lanes	10000				11300		
11 foot lanes	9700				10900		
10 foot lanes	9300				10500		
9 foot lanes	9000				10200		

Uses "Principal Arterials" and "Minor Arterials" Facility Types in NCLOS

*** Decrease in Lane Width Capacity calculated via 2000 Highway Capacity Manual lane-width adjustment factor for saturation flow rate**

See Appendix E1 for HCM 2000 Urban Arterial Equations
Use Appendix E4: Mountain Minor Thoroughfare Inputs for adjustments

NOTE: Lane Width is adjusted downward by 3.33% per less foot of pavement

Level of Service D Standards for Rural 2-Lane Highways

Coastal 2-Lane Highway Standard	COASTAL		
	Minimum	Standard	Maximum
12-Foot Lanes	10500	12700*	14700*#
11-Foot Lanes	10000		
10-Foot Lanes	9200	12000	
9-Foot Lanes	7700	10700	

Piedmont 2-Lane Highway Standard	PIEDMONT		
	Minimum	Standard	Maximum
12-Foot Lanes	10300	12400*	14300*#
11-Foot Lanes	9900		
10-Foot Lanes	9000	11800	
9-Foot Lanes	7500	10500	

Mountain 2-Lane Highway Standard	MOUNTAINS (Level)		
	Minimum	Standard	Maximum
12-Foot Lanes	10200	12100*	14000*#
11-Foot Lanes	9800		
10-Foot Lanes	8800	11700	
9-Foot Lanes	7400	10300	

Mountain 2-Lane Highway Standard	MOUNTAINS (Rolling)		
	Minimum	Standard	Maximum
12-Foot Lanes	9600	12100*	14000*#
11-Foot Lanes	9100		
10-Foot Lanes	8200	11100	
9-Foot Lanes	6300	9800	

Uses "2-Lane Highways" Facility Type in NCLOS

*** All capacities calculated based on HCM 2000 procedures using HCS software. Under some conditions, two-lane highway capacity is not affected by lane width. This occurs where capacity is governed by Percent Time Spent Following rather than by Average Travel Speed.**

 # Best-case/Maximum conditions are less likely to occur where lane widths are below 11 feet. Use caution before selecting "Maximum" values for 9-ft or 10-ft lanes.

See Appendix F1 for HCM 2000 2-Lane Highway Equations
Use Appendix F2: Coastal Rural 2-Lane Highway Inputs for adjustments
Use Appendix F3: Piedmont Rural 2-Lane Highway Inputs for adjustments
Use Appendix F4: Mountain (Level) Rural 2-Lane Highway Inputs for adjustments
Use Appendix F5: Mountain (Rolling) Rural 2-Lane Highway Inputs for adjustments

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