AUBURN • OPELIKA TRANSPORTATION 2050 LONG RANGE PLAN

TECHNICAL REPORT #1

Travel Demand Model Update

LEE-RUSSELL COUNCIL OF GOVERNMENTS

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1.0 Introduction

This report includes a description of the procedures used in developing the updated demographics and travel estimates used in the Long Range Transportation Plan (LRTP) for the Auburn-Opelika Metropolitan Planning Organization (AOMPO). It also describes the relationship between planning data and trip making and the calibration and testing of the model. Instructions on how to operate the model are not contained within this report.

The AOMPO Travel Demand Model (TDM) serves as an updated version of the MPO's model for use in the LRTP. The updated model was calibrated and validated to meet the requirements established by the Federal Highway Administration (FHWA) and uses the calibration and validation parameters described in the latest Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee.

The updated TDM continues to use the 2023 base year. Additional updates to the TDM include:

- updated master roadway network;
- updated Traffic Analysis Zones (TAZs);
- updated socioeconomic data and trip rates; and
- updated turn penalties, capacity factors, and external trip data.

The TDM is based upon the conventional trip-based four-step modeling approach. Broadly, the main model components fall within the following four categories:

- **Trip Generation** - The process of estimating trip productions and attractions at each TAZ.
- **Trip Distribution** - The process of linking trip productions to trip attractions for each TAZ pair.
- **Mode Choice** - The process of estimating the number of trips by mode for each TAZ pair. This process allows the model to calculate transit trips.
- **Trip Assignment** - The process of assigning auto and truck trips onto specific highway facilities in the region.

The TDM's focus is on the region's highway network due to a limited number of transit trips. As a result, a transit element has not been included, eliminating the mode choice step.

The TDM was developed in TransCAD 9.0 Build 32950 64-bit travel demand forecasting software and the model interface was developed using GISDK macros.

2.0 Traffic Analysis Zones and Socioeconomic Data

2.1 Study Area and Traffic Analysis Zones

To facilitate the accuracy necessary for generating trips from planning data, the data is required to be aggregated by small geographic areas, called Traffic Analysis Zones (TAZs).

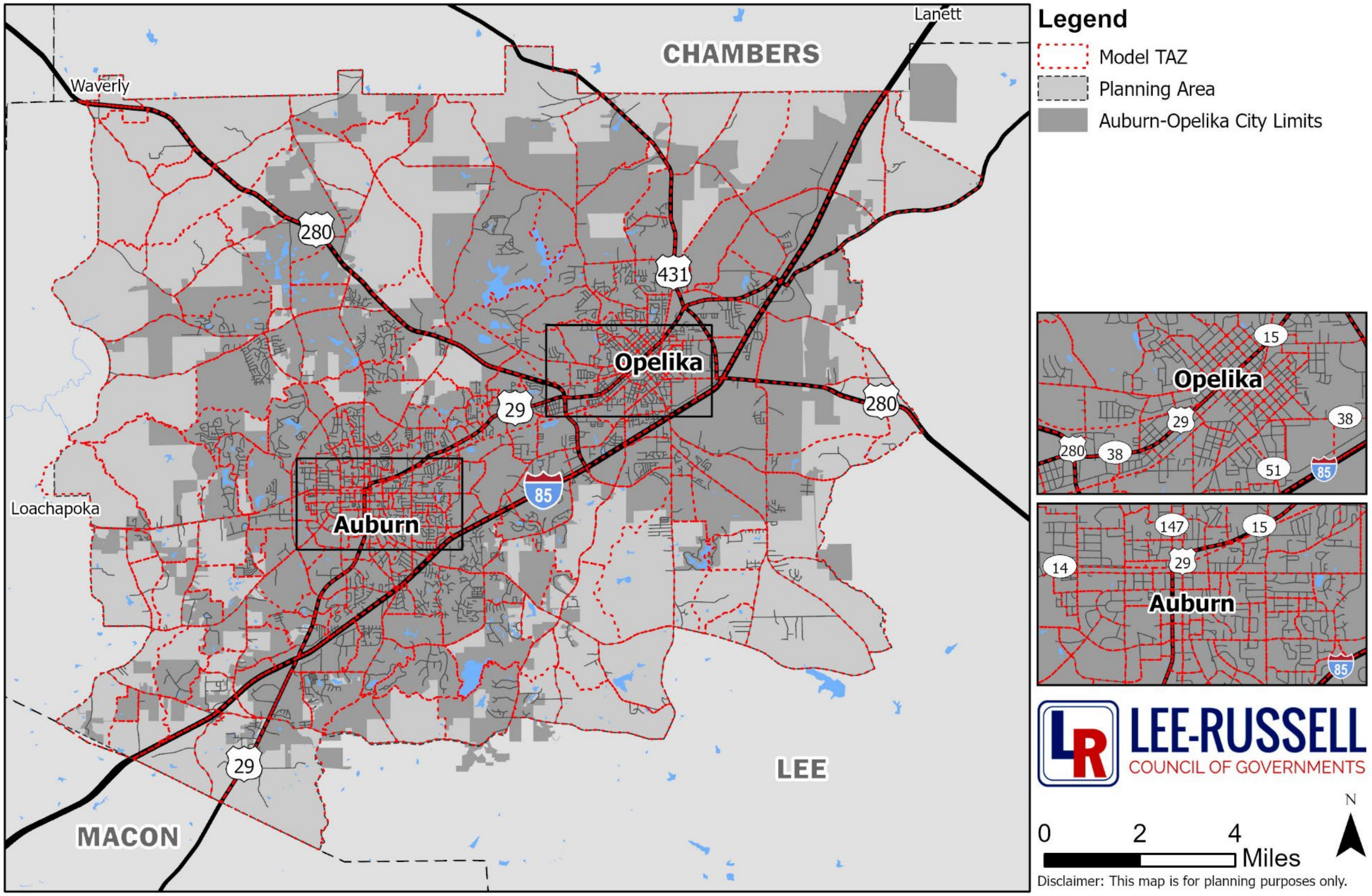
These TAZs are generally homogeneous areas and are delineated based on:

- population,
- land use,
- census geography,
- physical landmarks, and
- governmental jurisdictions.

The AOMPO study area and TAZ structure were updated from the MPO's previous model. The AOMPO study area was divided into 398 TAZs. The area has 367 TAZs in the Auburn-Opelika Metropolitan Planning Area (MPA). Additionally, there are 31 external stations.

The study area is comprised of a portion of Lee County, the City of Auburn, the City of Opelika, and a portion of the Town of Waverly as shown in **Figure 2.1.**

Figure 2.1: LRTP Model TAZs



Source: AOMPO TDM, NSI

2.2 Base Year (2023) Model Socioeconomic Data Update

This TDM effort uses a 2023 base year that includes housing, employment, and school attendance data as model inputs. This section describes the procedures used to update the model files to create the updated base year socioeconomic data.

Household Data Update

Household data for the model's TAZs were developed using:

- Census 2020 block data

Each TAZ within the model study area is comprised of one or more Census blocks. Using Geographic Information Systems (GIS) mapping, a layer stores the blocks and their information, including:

- TAZ
- 2020 total dwelling units (DU)
- households (a.k.a. occupied dwelling units, OCCDU)
- group quarter population (POPGQ)
- household population (POP)
- total population (TOTPOP)

This data was aggregated to the TAZ level, resulting in 2020 DU, OCCDU, POP, POPGQ, and TOTPOP by TAZ and then used to develop each TAZ's percent of dwelling units that are occupied and the zone's average household size.

TOTPOP was then scaled up using the American Community Survey (ACS) 2023 5-year estimates to obtain year 2023 population data by TAZ. The POPGQ was subtracted from the TOTPOP to obtain the 2023 POP values. Using the 2023 POP values and the 2020 average household size, year 2023 OCCDU totals were calculated. 2023 DU values were obtained by dividing the 2023 OCCDU by the 2020 percent occupied.

Table 2.1 displays the updated household data within the model study area.

Table 2.1: Study Area Households and Population, Base Year 2023

Variable	Study Area Total
Dwelling Units	58,583
Occupied Dwelling Units	53,685
Household Population	116,649

Source: Census, AOMPO TDM, NSI, 2023

Employment Data Update

For this effort, Quarterly Census of Employment and Wages (QCEW) data was used as it represents an accurate number of employees in the area with some minor exceptions and represents what has been reported to the Bureau of Labor Statistics.

The employment by TAZ and type was calculated and then adjusted proportionately by TAZ to meet the County's control totals. The control total for the model area was calculated by using input from the County and analyzing the QCEW employment data in the County for year 2023 and taking the proportion of employment within the model area compared to the County total.

Table 2.2 displays the study area employment by type. For modeling purposes, employment variables were differentiated into the following categories:

- Agriculture, Mining, and Construction (NAICS 11, 21, 23)
- Manufacturing, Transportation/Communications/Utilities, and Wholesale Trade (NAICS 31-33, 48-49, 23, 42)
- Retail Trade (NAICS 44-45, NAICS 723)
- Government, Office, and Services (NAICS 51-56, 61, 62, 71, 721, 81, 92)
- Other Employment (NAICS 99)

Table 2.2: Study Area Employment Classifications, Base Year 2023

Variable	Description	Study Area Total
TOT_EMP	Total Employment	87,338
AMC_EMP	Agriculture, Mining, and Construction	3,712
MTCUW_EMP	Manufacturing, Transportation/ Communications/ Utilities, and Wholesale Trade	12,053
RET_EMP	Retail Trade	24,417
OS_EMP	Government, Office, and Services	47,100
OTH_EMP	Other Employment	56

Source: QCEW, AOMPO TDM, NSI, 2023

School Enrollment Data Update

The LRTP's TDM obtained school attendance data from the U.S. Department of Education through the National Center for Education Statistics data tool[1]. School attendance figures include:

- Public and private elementary, middle, and high schools
- Colleges and universities
- Vocational and business schools

The total school attendance in the study area in 2023 was 53,822 in the Auburn-Opelika MPO. For modeling purposes, the school attendance is measured by the number of students attending a school in a TAZ and not by the number of students residing in that TAZ.

TAZ Data

The socioeconomic data for each TAZ is included in the TDM files. This data has been updated for the new 2023 base year. The fields used in the TAZ layer are shown **Table 2.3**.

Table 2.3: TAZ Field Attributes

Attribute Name	Description
ID	Integer (4 bytes) TAZ ID
AREA	Real (8 bytes) TAZ Area in Map Units
MODEL_TAZ	Integer (4 bytes) TAZ ID
STATEFP20	Character 2020 State ID
COUNTYFP20	Character 2020 County ID
TRACTCE20	Character 2020 Census Tract ID
PUMA5	Character 2020 Public Use Micro Area 5-digit ID
PUMA5_INT	Integer (4 bytes) 2020 Public Use Micro Area 5-digit ID; Integer format
AREA_TYTPE	Character Urban or Rural area type

[1] National Center for Education Statistics (NCES) - Data & Tools - Most Popular Tools

3.0 Roadway Network

3.1 Network Line Layer

The simulation of travel patterns in a computer model requires a representation of the street and highway system in digital format. The TransCAD model creates such a network from a geographic line layer in GIS. The line layer dataview records contain descriptive information for each link and its properties. Turn prohibitions are also coded into the network at locations where certain movements are not allowed or physically cannot be made.

Adjustments were made to the model network to update it to the new base year. These adjustments included:

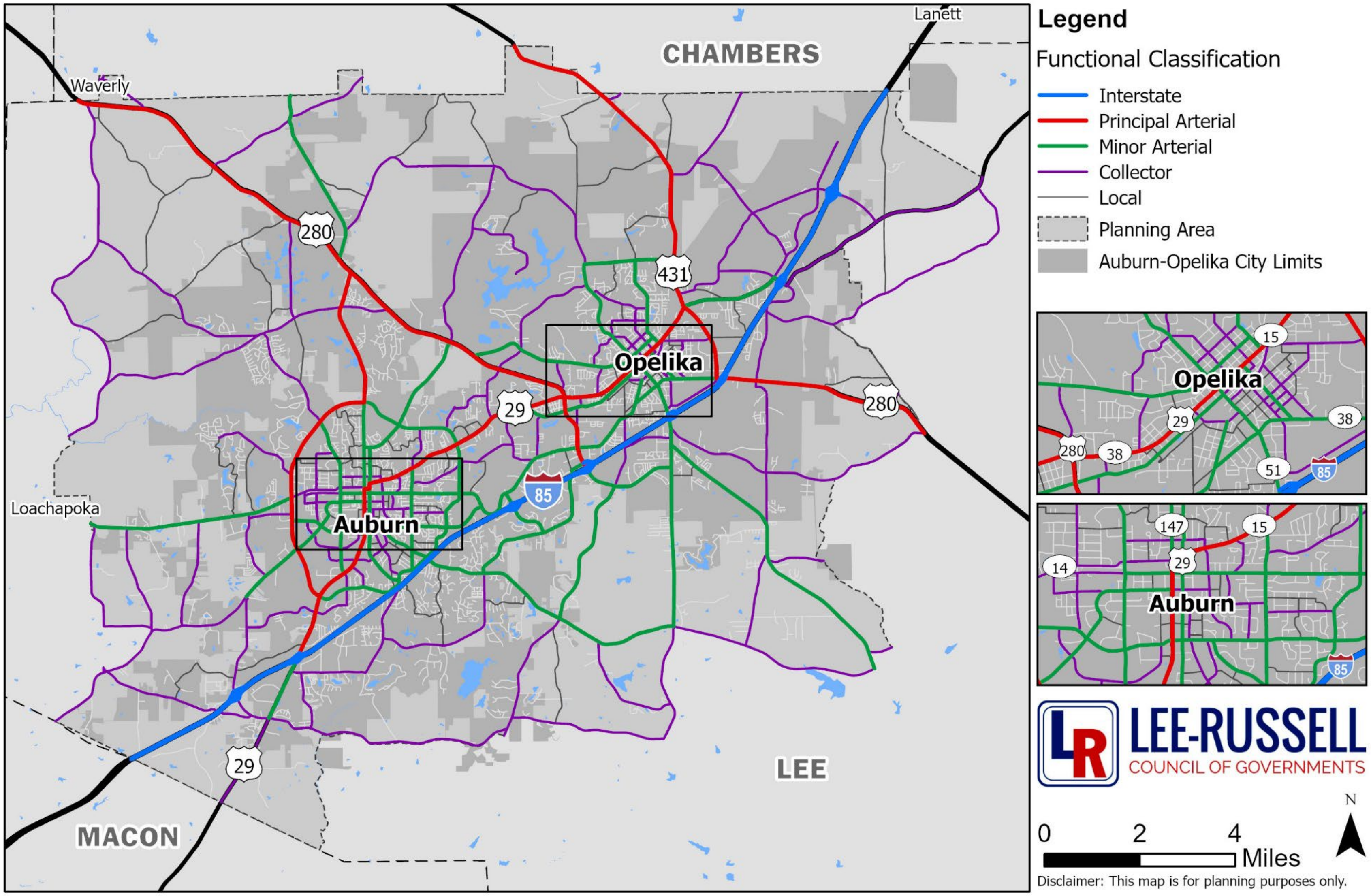
- number of lanes,
- speeds,
- functional classification,
- roadway capacity and capacity factors,
- volume-delay function parameters (alpha and beta values), and
- daily traffic counts and traffic stations (to 2023 where possible).

In addition to the changes listed above, the updated TDM features a master network in the model's setup folder. This line layer contains records for all roadway links used in the TDM process. The master network contains the data for the base year, Existing Plus Committed network, and all roadway test projects. **Figure 3.1** displays the 2023 base year roadway network used in the TDM.

3.2 Functional Classification

Each link in the model's roadway network was assigned a functional classification based on the federal functional classification system. This system is maintained by ALDOT. The functional classifications used in the TDM are shown in **Table 3.1**. **Table 3.2** and **Table 3.3** show the model link classes and model functional classifications, respectively, that were developed for the TDM.

Figure 3.1: 2023 Roadway Functional Classification



Source: ALDOT, AOMPO TDM, NSI

Table 3.1: ALDOT Functional Classifications Used in AOMPO Model

Code	Description
0	Centroid Connector
1	Interstate
2	Other Freeways and Expressways
3	Principal Arterial
4	Minor Arterial
5	Major Collector
6	Minor Collector
7	Local

Source: FHWA, ALDOT

Table 3.2: Model Link Classes Used in AOMPO Model

Code	Description
11	One lane, one way
12	One lane (each dir.), two way
14	One lane (each dir.), two way with left turn lanes, median, or boulevard
16	One lane (each dir.), two way with center turn lane
21	Two lanes, one way
22	Two lanes (each dir.), two way
24	Two lanes (each dir.), two way with left turn lanes, median, or boulevard
26	Two lanes (each dir.), two way with center turn lane
31	Three lanes, one way
34	Three lanes (each dir.), two way with left turn lanes, median, or boulevard
36	Three lanes (each dir.), two way with center turn lane
41	Four lanes, one way
44	Four lanes (each dir.), two way with left turn lanes, median, or boulevard

Source: NSI

Table 3.3: Model Functional Classifications Used in AOMPO Model

Code	Description
1	Rural Interstate
2	Rural Principal Arterial Divided
21	Rural Principal Arterial Undivided
3	Rural Minor Arterial Divided
31	Rural Minor Arterial Undivided
4	Rural Major Collector
41	Rural Major Collector Undivided
5	Rural Minor Collector
51	Rural Minor Collector Divided
6	Rural Local
61	Rural Local Undivided
10	Rural On/Off Ramp
11	Urban Interstate
12	Urban Expressway
14	Urban Principal Arterial Divided
141	Urban Principal Arterial Undivided
16	Urban Minor Arterial Divided
161	Urban Minor Arterial Undivided
17	Urban Major Collector
171	Urban Major Collector Undivided
18	Urban Minor Collector
181	Urban Minor Collector Undivided
19	Urban Local
191	Urban Local Undivided
20	Rural On/Off Ramp
99	Centroid Connector

Source: NSI

3.3 Posted Speed and Capacity

Posted speeds and capacities are important TDM inputs that affect the traffic assignment model. The posted speed is derived from WAZE data for each roadway link and is contained in the network database. The model uses the capacity factors shown in **Figure 3.2**. These key model inputs were assigned to each individual network link. These inputs consider factors such as:

- Roadway posted speed
- Roadway functional classification
- Location of roadway in urban or rural area
- Link Capacity
- Number of lanes
- Width of travel lanes
- Presence of a median or dividing feature
- Presence of a center turn lane
- Presence of on-street parking
- Width of shoulder on roadway

Figure 3.2: Model Capacity Factors

Link Capacity (LOS D)

Vehicles per lane per hour - vphpl

Functional Class		vphpl Directional
All Interstate		
2 Lanes		2,300
>2 Lanes		2,400
Principal Arterial		
Rural	Divided	1,700
Rural	Undivided	1,500
Urban	Divided	1,500
Urban	Undivided	1,300
Minor Arterial		
Rural	Divided	1,600
Rural	Undivided	1,350
Urban	Divided	1,400
Urban	Undivided	1,150
Collector		
Rural	Divided	1,350
Rural	Undivided	1,150
Urban	Divided	1,150
Urban	Undivided	950
Local		
Rural	2 Lane	900
Rural	>2 Lane	1,000
Urban	2 Lane	800
Urban	>2 Lane	900
Ramps		1,000
Centroid Connectors		9,999

SF = c x N x Fw x Fhv x Fp x Fe x Fd x Fctl x Fpark X (V/C)i

SF = Model vphpl for desired level of service
c = Ideal vphpl
N = Number of Lanes
(V/C)I = Rate of service flow for level of service D

Adjustment Factors

Acronym	Name	Facility Type	Lane	Shoulder	Factor
Fw	Lane & Shoulder Width	Interstate & Sys Ramp	<=10'	0-<2'	0.78
		Interstate & Sys Ramp	<=10'	2'-5'	0.83
		Interstate & Sys Ramp	<=10'	>5'	0.88
		Interstate & Sys Ramp	>10'	0-<2'	0.90
		Interstate & Sys Ramp	>10'	2'-5'	0.95
		Interstate & Sys Ramp	>10'	>5'	1.00
		Principal Arterial Div	<=10'	0-<2'	0.78
		Principal Arterial Div	<=10'	2'-5'	0.83
		Principal Arterial Div	<=10'	>5'	0.88
		Principal Arterial Div	>10'	0-<2'	0.92
		Principal Arterial Div	>10'	2'-5'	0.96
		Principal Arterial Div	>10'	>5'	1.00
		Principal Arterial Undiv	<=10'	0-<2'	0.78
		Principal Arterial Undiv	<=10'	2'-5'	0.82
		Principal Arterial Undiv	<=10'	>5'	0.86
		Principal Arterial Undiv	>10'	0-<2'	0.90
		Principal Arterial Undiv	>10'	2'-5'	0.95
		Principal Arterial Undiv	>10'	>5'	1.00
		Minor Arterial Div	<=9'	0-<2'	0.81
		Minor Arterial Div	<=9'	2'-5'	0.86
		Minor Arterial Div	<=9'	>5'	0.93
		Minor Arterial Div	>9'	0-<2'	0.94
		Minor Arterial Div	>9'	2'-5'	1.00
		Minor Arterial Div	>9'	>5'	1.05
		Minor Arterial Undiv	<=9'	0-<2'	0.77
		Minor Arterial Undiv	<=9'	2'-5'	0.83
		Minor Arterial Undiv	<=9'	>5'	0.88
		Minor Arterial Undiv	>9'	0-<2'	0.89
		Minor Arterial Undiv	>9'	2'-5'	0.95
		Minor Arterial Undiv	>9'	>5'	1.00
		Collector Div	<=9'	0-<2'	0.81
		Collector Div	<=9'	2'-5'	0.86
		Collector Div	<=9'	>5'	0.93
		Collector Div	>9'	0-<2'	0.96
		Collector Div	>9'	2'-5'	1.00
		Collector Div	>9'	>5'	1.05
		Collector Undiv	<=9'	0-<2'	0.81
		Collector Undiv	<=9'	2'-5'	0.85
		Collector Undiv	<=9'	>5'	0.90
		Collector Undiv	>9'	0-<2'	0.94
		Collector Undiv	>9'	2'-5'	1.00
		Collector Undiv	>9'	>5'	1.04
		Local 2 Lane	<=9'	0-<2'	0.65
		Local 2 Lane	<=9'	2'-5'	0.78
		Local 2 Lane	<=9'	>5'	0.90
		Local 2 Lane	>9'	0-<2'	0.85
		Local 2 Lane	>9'	2'-5'	1.00
		Local 2 Lane	>9'	>5'	1.04
		Local >2 Lane	<=9'	0-<2'	0.81
		Local >2 Lane	<=9'	2'-5'	0.85
		Local >2 Lane	<=9'	>5'	0.92
		Local >2 Lane	>9'	0-<2'	0.96
		Local >2 Lane	>9'	2'-5'	1.00
		Local >2 Lane	>9'	>5'	1.10
Fhv	Heavy Vehicle	Interstate			0.88
		Principal Arterial			0.90
		Minor Arterial			0.90
		Collector			0.92
		Local			0.97
Fp	Driver Population	Rural Interstate			0.90
		Urban Interstate			0.92
		System Ramp			0.92
		Principal Arterial			0.95
		Minor Arterial			0.98
		Collector			NA
		Local			NA
Fe	Driving Environment	Interstate			NA
		Rural Prin Art	Divided		1.00
		Rural Prin Art	Undivided		0.90
		Urban Prin Art	Divided		0.90
		Urban Prin Art	Undivided		0.80
		Rural Minor Art	Divided		1.00
		Rural Minor Art	Undivided		0.90
		Urban Minor Art	Divided		0.90
		Urban Minor Art	Undivided		0.80
		Rural Collector	Divided		1.00
		Rural Collector	Undivided		0.90
		Urban Collector	Divided		0.90
		Urban Collector	Undivided		0.80
		Rural Local	2 Lane		0.90
		Rural Local	>2 Lane		0.90
		Urban Local	2 Lane		0.80
		Urban Local	>2 Lane		0.80
Fd	Directional Distribution (Local only)	2 Lane	Divided		0.94
		>2 Lane	Divided		1.16
		2 Lane	Undivided		0.94
		>2 Lane	Undivided		1.10
Fctl	Center Turn Lane	Interstate			NA
		All Other			1.08
Fpark	On Street Parking	Any			0.95

Source: Highway Capacity Manual, GNRC/Nashville MPO Model

3.4 Network Attributes

Table 3.4 displays the network attributes used on the links in the TDM, while **Table 3.5** displays the attributes used in the node layer.

Table 3.4: AOMPO Model Link Attributes

Attribute Name	Description	Input Type
ID	Integer (4 bytes) TransCAD automatic Field ID	Automatic, but user can override
Dir	Integer (2 bytes) 0 = Two-way link 1= One-way link, AB fields will be used -1= One-way link, BA fields will be used	Automatic, but user can override
Length	Real (8 bytes) Map unit length of link	Automatic
Name	Character Roadway name	User
Screenline	Integer (4 bytes) Screenline ID	User
External	Integer (4 bytes) External station link	User
ADT_23	Integer (4 bytes) 2023 average daily traffic count	User
MTRK_23	Real (8 bytes) 2023 daily medium truck traffic count	User
HTRK_23	Real (8 bytes) 2023 daily heavy truck traffic count	User
Begin_2023_Fields	Character Beginning of 2023 attribute fields	User
DIR_23	Integer (2 bytes) 0 = Two-way link 1= One-way link, AB fields will be used -1= One-way link, BA fields will be used	User*
NETWORK_23	Integer (2 bytes) 1= Included in model run 2= Centroid Connector 0 or null = Link will not be included in the model scenario run	User*
FC_23	Integer (2 bytes) Refer to Table 3.1	User*

Attribute Name	Description	Input Type
FC_DESC_23	Character Roadway functional class name	User*
AB_FC_23	Integer (2 bytes) Refer to Table 3.1	User*
BA_FC_23	Integer (2 bytes) Refer to Table 3.1	User*
MODEL_FC_23	Integer (2 bytes) Refer to Table 3.3	User*
MODEL_FC_DESC_23	Character Roadway model functional class name	User*
URB_RUR_23	Integer (2 bytes) Urban or Rural roadway	User
AB_CLASS_23	Integer (2 bytes) See Table 3.2	User*
BA_CLASS_23	Integer (2 bytes) See Table 3.2	User*
LANES_23	Integer (2 bytes) Number of lanes of the roadway	User*
AB_LANES_23	Integer (2 bytes) Number of lanes in AB direction	User*
BA_LANES_23	Integer (2 bytes) Number of lanes in BA direction	User*
POSTED_SPEED_23	Integer (4 bytes) Posted link speed (MPH)	User
AB_SPEED_23	Real (8 bytes) Link speed (MPH) in AB direction	User*
BA_SPEED_23	Real (8 bytes) Link speed (MPH) in BA direction	User*
ALPHA_23	Real (4 bytes) BPR Volume-Delay Function Parameter	User*
BETA_23	Real (4 bytes) BPR Volume-Delay Function Parameter	User*
AB_TT_23	Real (8 bytes) Link travel time in AB direction, minutes	Model
BA_TT_23	Real (8 bytes) Link travel time in BA direction, minutes	Model
AB_TT_AM_23	Real (8 bytes) Morning link travel time in AB direction	Model
BA_TT_AM_23	Real (8 bytes) Morning link travel time in BA direction	Model

Attribute Name	Description	Input Type
AB_TT_MD_23	Real (8 bytes) Mid-day link travel time in AB direction	Model
BA_TT_MD_23	Real (8 bytes) Mid-day link travel time in BA direction	Model
AB_TT_PM_23	Real (8 bytes) Afternoon link travel time in AB direction	Model
BA_TT_PM_23	Real (8 bytes) Afternoon link travel time in BA direction	Model
AB_TT_NT_23	Real (8 bytes) Nighttime link travel time in AB direction	Model
BA_TT_NT_23	Real (8 bytes) Nighttime link travel time in BA direction	Model
AREA_TYPE_23	Integer (2 bytes) 1 = Urban 2 = Rural	User
DIV_23	Integer (4 bytes) 0 = Roadway not divided 1 = Divided roadway	User
Parking_23	Integer (4 bytes) 0 = No on-street parking present 1 = On-street parking present	User
Shoulder_23	Integer (4 bytes) Width of shoulder	User
CTL_23	Integer (4 bytes) 0 = No center turn lane Present 1 = Center turn lane Present	User
Fw_23	Real (8 bytes) Capacity factor for lane and shoulder width	User*
Fhv_23	Real (8 bytes) Capacity factor for heavy vehicles	User*
Fp_23	Real (8 bytes) Capacity factor for driver population	User*
Fe_23	Real (8 bytes) Capacity factor for driving environment	User*
Fd_23	Real (8 bytes) Capacity factor for directional distribution	User*
Fctl_23	Real (8 bytes) Capacity factor for center turn lanes	User*
Fpark_23	Real (8 bytes) Capacity factor for on-street parking	User*

Attribute Name	Description	Input Type
Fall_23	Real (8 bytes) Overall capacity factor	User*
IDEAL_VPHPL_23	Real (8 bytes) Maximum capacity in vehicles/hour/lane	User*
AB_VPHPL_23	Real (8 bytes) Capacity in AB direction in vehicles/hour/lane	User*
BA_VPHPL_23	Real (8 bytes) Capacity in AB direction in vehicles/hour/lane	User*
IS_MANUAL_CAP_23	Integer (2 bytes) Manual capacity input	User
AB_CAPACITY_23	Integer (4 bytes) Daily capacity in AB direction	User
BA_CAPACITY_23	Integer (4 bytes) Daily capacity in BA direction	User
AB_CAP_AM_23	Integer (4 bytes) Morning peak period capacity in AB direction	Model
BA_CAP_AM_23	Integer (4 bytes) Morning capacity in BA direction	Model
AB_CAP_MD_23	Integer (4 bytes) Mid-day capacity in AB direction	Model
BA_CAP_MD_23	Integer (4 bytes) Mid-day capacity in BA direction	Model
AB_CAP_PM_23	Integer (4 bytes) Afternoon peak period capacity in AB direction	Model
BA_CAP_PM_23	Integer (4 bytes) Afternoon peak period capacity in BA direction	Model
AB_CAP_NT_23	Integer (4 bytes) Nighttime capacity in AB direction	Model
BA_CAP_NT_23	Integer (4 bytes) Nighttime capacity in BA direction	Model
Begin_Output_Fields	Character Beginning of model output fields	User
DAILY_FLOW	Real (8 bytes) Total daily model volume	Model
AB_DAILY_FLOW	Real (8 bytes) AB directional daily model volume	Model
BA_DAILY_FLOW	Real (8 bytes) BA directional daily model volume	Model
DAILY_TOT_VMT	Real (8 bytes) Total daily vehicle miles travelled	Model

Attribute Name	Description	Input Type
DAILY_AB_VMT	Real (8 bytes) AB directional daily vehicle miles travelled	Model
DAILY_BA_VMT	Real (8 bytes) BA directional daily vehicle miles travelled	Model
DAILY_TOT_VHT	Real (8 bytes) Total daily vehicle hours travelled	Model
DAILY_AB_VHT	Real (8 bytes) AB directional daily vehicle hours travelled	Model
DAILY_BA_VHT	Real (8 bytes) BA directional daily vehicle hours travelled	Model
DAILY_TOT_VHD	Real (8 bytes) Total daily vehicle hours of delay	Model
DAILY_AB_VHD	Real (8 bytes) AB directional daily vehicle hours of delay	Model
DAILY_BA_VHD	Real (8 bytes) BA directional daily vehicle hours of delay	Model
DAILY_MAX_VOC	Real (8 bytes) Higher of AB and BA volume/capacity	Model
DAILY_AB_VOC	Real (8 bytes) AB directional volume/capacity	Model
DAILY_BA_VOC	Real (8 bytes) BA directional volume/capacity	Model
DAILY_TRK_FLOW	Real (8 bytes) Total daily model truck volume	Model
AB_DAILY_TRK_FLOW	Real (8 bytes) AB directional daily model truck volume	Model
BA_DAILY_TRK_FLOW	Real (8 bytes) AB directional daily model truck volume	Model
DAILY_TOT_TRK_VMT	Real (8 bytes) Total daily truck miles travelled	Model
DAILY_AB_TRK_VMT	Real (8 bytes) AB directional daily truck miles travelled	Model
DAILY_BA_TRK_VMT	Real (8 bytes) BA directional daily truck miles travelled	Model
DAILY_TOT_TRK_VHT	Real (8 bytes) Total daily truck hours travelled	Model
DAILY_AB_TRK_VHT	Real (8 bytes) AB directional daily truck hours travelled	Model
DAILY_BA_TRK_VHT	Real (8 bytes) BA directional daily truck hours travelled	Model

Attribute Name	Description	Input Type
DAILY_TOT_TRK_VHD	Real (8 bytes) Total daily truck hours of delay	Model
DAILY_AB_TRK_VHD	Real (8 bytes) AB directional daily truck hours of delay	Model
DAILY_BA_TRK_VHD	Real (8 bytes) BA directional daily truck hours of delay	Model
Notes: 1. Each of the suffix "23" fields should be repeated for EC, VIS, and SCE suffixes as well. 2. Volume-delay function parameter fields Alpha_23 and Beta_23 are based on BPR function. 3. In addition to the base year fields, each planned year should have a field called "PROJECT_[suffix]" of type Integer. This field should have a unique project number for each committed or planned project. 4. *: These values are required when adding and/or modifying a roadway link. 5. User does not need to input values of fields whose "INPUT TYPE" is 'Model'. Model interface will calculate the values of these fields.		

Table 3.5: AOMPO Model Node Attributes

Attribute Name	Description
ID	Integer (4 bytes) For centroids keep the ID the same as TAZ number.
LONGITUDE	Integer (4 bytes) TCAD automatic field
LATITUDE	Integer (4 bytes) TCAD automatic field
CENTROID	Integer (4 bytes) TAZ number for centroid

3.5 Centroid Connectors

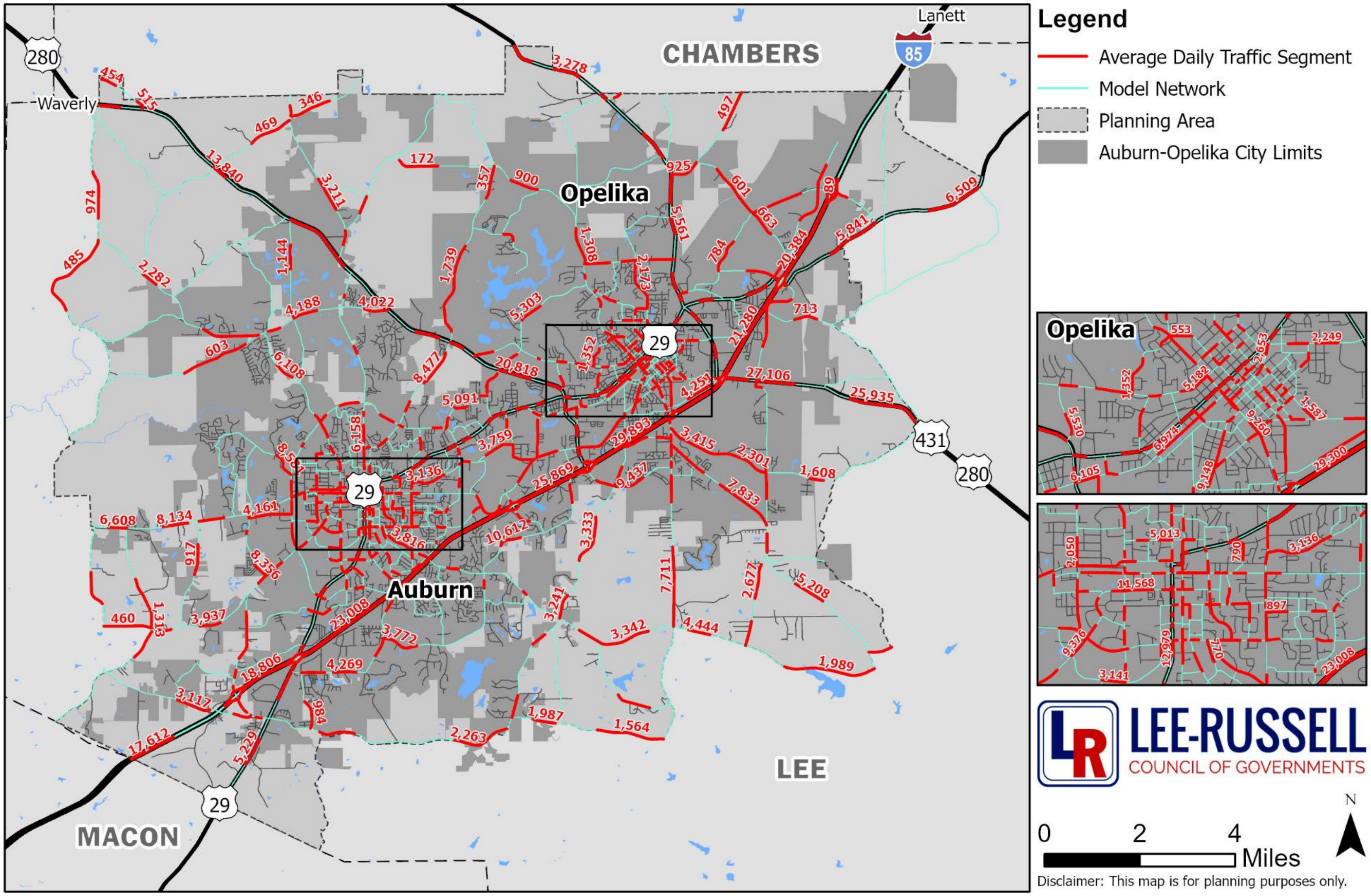
Centroid connectors are imaginary roadway network links that connect the TAZ centroid to the adjacent roadway network at nodes. These links represent the local streets on the street and highway system that are not in the model network. Centroid connectors provide the model the ability to move trips generated from individual TAZs to the roadway network. The location where centroid connectors access the model network is based on features such as neighborhood roadway entrances, driveways, and parking lots.

During the TDM update, the centroid connectors were adjusted to match locations where traffic is most likely to access the model's roadways. These adjustments were accomplished by relocating the centroid for the TAZ to reflect the "center of mass" of developed land and/or by moving the centroid connector roadway network access points to a location where trips generally enter or leave the TAZ. This action changes the length of the centroid connectors and the travel times on the links to encourage modeled traffic to use certain access points to reflect the observed traffic.

3.6 Traffic Counts

The updated model also contains updated traffic counts in the roadway network. These counts come from ALDOT and are the most recent available. The update process included verifying the count stations on the existing TDM links and assigning the ADTs to the correct link. Where a 2023 ADT was not available for a count station, the most recent count was factored to the base year using growth rate data from historical counts. The traffic ADTs used in the TDM are shown in **Figure 3.3**.

Figure 3.3: 2023 Roadway Traffic Counts



Source: ALDOT, AOMPO TDM, NSI

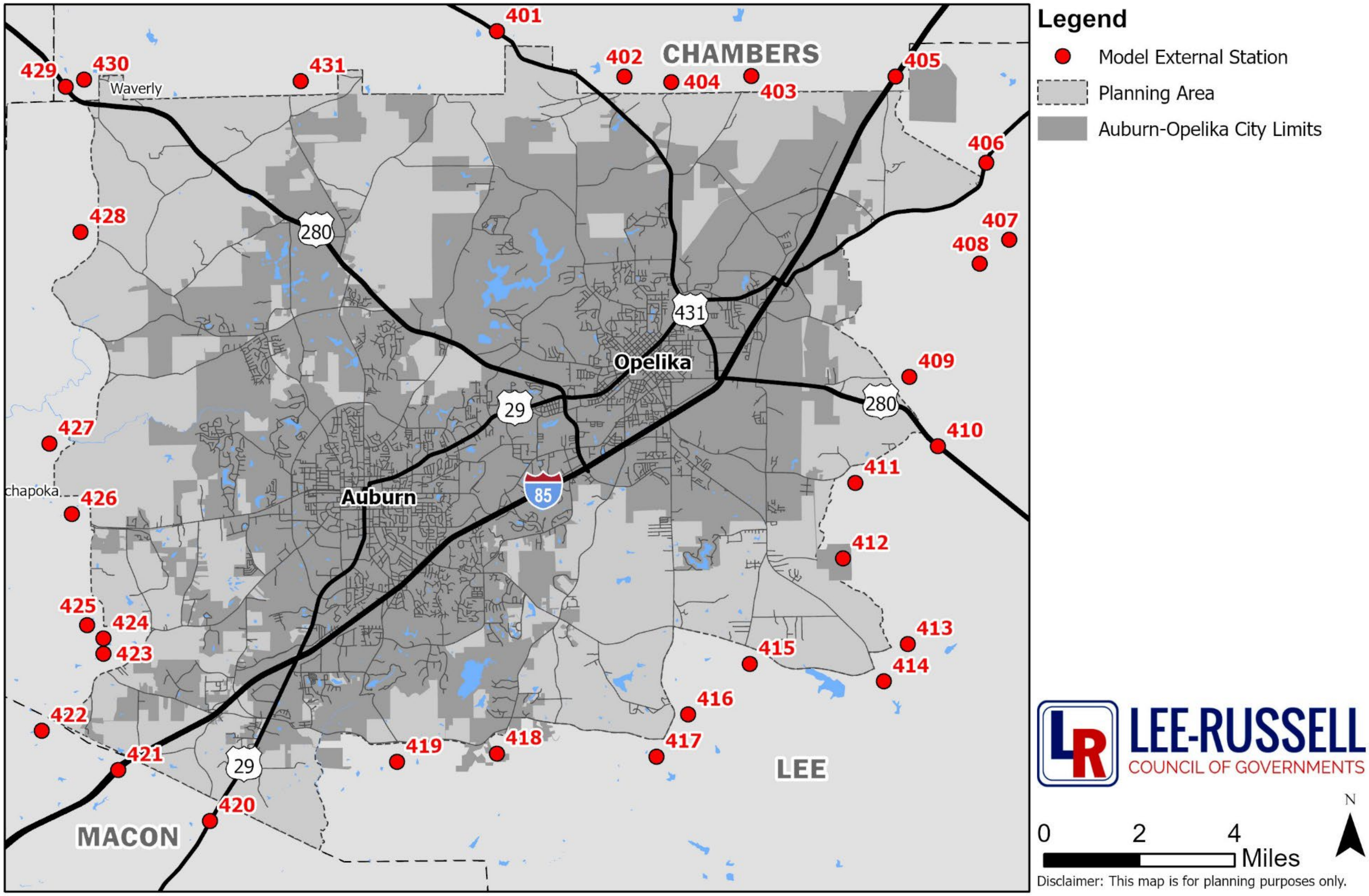
4.0 External Travel

There are two types of external travel trips: external-internal (EI) trips and external-external (EE) trips. These trips are further described as follows:

- EI trips have one end of the trip inside the study area and the other end outside. EI trips can apply to trips originating within the study area and leaving or trips originating outside of the study area and stopping within the study area.
- EE trips pass through the study area. They have no origin or destination within the study area itself.

Both trip types are assigned at external stations located on significant roadways that are at the periphery of the study area. These stations represent most trips that are crossing the study area boundary. Since changes were made to the study area and additional roadways were added to the network that crossed the study area boundary, the external stations were changed to reflect this update in the model. The locations of the TDM's external stations are shown in **Figure 4.1**.

Figure 4.1: LRTP Model External Stations



Source: ALDOT, AOMPO TDM, NSI

4.1 Development of EE Trips

The EE trips that pass through the study area are represented by a matrix in the model. This matrix represents the daily vehicle trips going from one external station to the other external stations of the study area.

The percentage of EE and EI trips, as well as the auto and truck trip percentages, were created for this TDM using the data obtained from Replica Platform. This data created an initial seed matrix for EE distribution. The Fratar Method was used to grow the EE trips to 2023 ADT counts.

External travel trips at each station are shown in **Table 4.1**. The full distribution of the EE trips can be found in the model input files.

Table 4.1: Study Area External-External Trips

Station ID	Description	ADT	% EE Trips	% EE AUTO	% EE TRK	Total EE Trips	EE AUTO Trips	EE TRK Trips
401	US 431	3,432	51.3%	45.1%	6.2%	1,760	1,549	211
402	CR-173	178	40.9%	39.3%	1.6%	73	70	3
403	CR-389	497	7.3%	7.2%	0.1%	37	36	1
404	CR-174	300	1.6%	1.6%	0.0%	5	5	0
405	I-85	40,746	50.4%	39.3%	11.1%	20,531	16,014	4,517
406	US 29	6,267	26.2%	25.2%	1.0%	1,639	1,578	61
407	CR-252	600	51.3%	46.7%	4.6%	308	280	28
408	CR-182	700	81.8%	74.4%	7.4%	573	521	52
409	CR-158	1,287	38.5%	32.6%	5.9%	496	420	76
410	US 280	22,177	27.8%	24.2%	3.6%	6,170	5,368	802
411	CR-151	217	36.4%	32.2%	4.2%	79	70	9
412	CR-148	454	22.6%	21.8%	0.8%	102	99	3
413	CR-145	653	23.8%	22.1%	1.7%	155	144	11
414	SR-169	5,600	17.3%	16.2%	1.1%	970	908	62
415	CR-166	2,816	9.7%	9.5%	0.2%	274	268	6
416	CR-400	3,079	34.2%	33.5%	0.7%	1,052	1,031	21
417	SR-51 (Marvyn Pkwy)	6,100	12.4%	11.8%	0.6%	754	722	32
418	CR-54	1,005	8.2%	8.0%	0.2%	82	80	2
419	CR-159	571	14.6%	14.3%	0.3%	83	82	1
420	US 29	4,800	5.2%	4.9%	0.3%	248	235	13
421	I-85	35,225	45.1%	33.3%	11.8%	15,895	11,738	4,157
422	CR-137	1,475	8.4%	8.2%	0.2%	124	120	4
423	CR-61	1,200	6.1%	5.4%	0.7%	73	65	8
424	CR-61	900	13.7%	12.2%	1.5%	123	110	13
425	CR-393	280	3.6%	3.6%	0.0%	10	10	0
426	SR-14	5,305	7.9%	7.2%	0.7%	420	385	35
427	CR-188	1,056	32.7%	31.6%	1.1%	345	334	11
428	CR-72	2,020	12.2%	11.7%	0.5%	246	236	10
429	US 280	13,475	32.0%	28.7%	3.3%	4,307	3,862	445
430	Patrick St	93	69.9%	65.6%	4.3%	65	61	4
431	SR-147	2,790	20.7%	20.3%	0.4%	577	565	12

Source: ALDOT, NSI, 2023

4.2 Development of EI Trips

During model development, EI trips (which include both internal-external and external-internal) were separated into auto and truck trips based on the vehicle classification counts at external stations. EI attraction equations were then estimated using the EITRK and EIAUTO attractions derived from Replica data and TAZ level demographic data. EITRK and EIAUTO attraction equations developed for this model update are shown below.

EIAUTO Attractions = (0.3571 * OCCDU) + (1.2163 * RET_EMP) + (1.2163 * RET_EMP2) + (0.6850 * OS_EMP) + (16.3619 * OTH_EMP) + (0.5172 * AMC_EMP)

EITRK Attractions = (0.0823 * OCCDU) + (0. 0052 * OS_EMP) + (3.4984 * OTH_EMP) + (0.2988 * AMC_EMP) + (0.4236 * MTCUW_EMP)

Table 4.2 displays the EI trips at each external station.

Table 4.2: Study Area External-Internal Trips

Station ID	Description	ADT	% EI Trips	% EI AUTO	% EI TRK	Total EI Trips	EI AUTO Trips	EI TRK Trips
401	US 431	3,432	48.7%	42.9%	5.8%	1,672	1,471	201
402	CR-173	178	59.1%	56.7%	2.4%	105	101	4
403	CR-389	497	92.7%	91.0%	1.7%	460	451	9
404	CR-174	300	98.4%	95.5%	2.9%	295	286	9
405	I-85	40,746	49.6%	38.7%	10.9%	20,215	15,768	4,447
406	US 29	6,267	73.8%	71.1%	2.7%	4,628	4,457	171
407	CR-252	600	48.7%	44.3%	4.4%	292	266	26
408	CR-182	700	18.2%	16.6%	1.6%	127	116	11
409	CR-158	1,287	61.5%	52.1%	9.4%	791	671	120
410	US 280	22,177	72.2%	62.8%	9.4%	16,007	13,926	2,081
411	CR-151	217	63.6%	56.3%	7.3%	138	122	16
412	CR-148	454	77.4%	75.2%	2.2%	352	341	11
413	CR-145	653	76.2%	70.9%	5.3%	498	463	35
414	SR-169	5,600	82.7%	77.4%	5.3%	4,630	4,335	295
415	CR-166	2,816	90.3%	88.5%	1.8%	2,542	2,491	51
416	CR-400	3,079	65.8%	64.5%	1.3%	2,027	1,986	41
417	SR-51 (Marvyn Pkwy)	6,100	87.6%	83.9%	3.7%	5,346	5,116	230
418	CR-54	1,005	91.8%	89.0%	2.8%	923	895	28
419	CR-159	571	85.4%	83.7%	1.7%	488	478	10
420	US 29	4,800	94.8%	89.9%	4.9%	4,552	4,315	237
421	I-85	35,225	54.9%	40.5%	14.4%	19,330	14,275	5,055
422	CR-137	1,475	91.6%	89.2%	2.4%	1,351	1,315	36
423	CR-61	1,200	93.9%	83.6%	10.3%	1,127	1,003	124
424	CR-61	900	86.3%	76.8%	9.5%	777	692	85
425	CR-393	280	96.4%	93.3%	3.1%	270	261	9
426	SR-14	5,305	92.1%	84.4%	7.7%	4,885	4,479	406
427	CR-188	1,056	67.3%	65.2%	2.1%	711	688	23
428	CR-72	2,020	87.8%	84.3%	3.5%	1,774	1,703	71
429	US 280	13,475	68.0%	61.0%	7.0%	9,168	8,220	948
430	Patrick St	93	30.1%	28.0%	2.1%	28	26	2
431	SR-147	2,790	79.3%	77.7%	1.6%	2,213	2,169	44

Source: ALDOT, NSI, 2023

5.0 Trip Generation

This section describes the procedures used to determine the number of trips that begin or end in a given traffic zone. Trip generation is the estimation of the number of person trips that are produced and attracted to each TAZ. Trip rates for the various types of trips are based upon the land use properties and demographic characteristics of each TAZ.

The model considers the following internal trip purposes:

- Home-Based Work (HBW)
- Home-Based Other (HBO)
- Non-Home Based (NHB)
- Commercial Vehicle (CMVEH)
- Freight (FRT a.k.a. TRK)

5.1 Internal Travel Mode

For home-based trips, the productions refer to the home end, and the attractions refer to the non-home end of the trip. For NHB, CMVEH, and FRT trips, productions and attractions refer to the origin and destination respectively. The model uses cross-classification trip production models for the home-based and non-home-based trip purposes which means that trip rates that vary by household type are applied at the zonal level. The trip attraction models are linear regression equations that relate zonal employment and households to trip attractions. For commercial vehicle and freight vehicle trip purposes, the model applies a linear regression equation that relates zonal employment and households to trip productions and attractions. These equations are based on the Quick Response Freight Manual.

The trip production and attraction models were developed based on the NCHRP 716 methodology and adjusted to meet the minimum calibration guidelines. These trip models were refined again for this update as needed during the calibration process and adjusted to meet the guidelines based on the updated socioeconomic data. The final trip generation production and attraction models for HBW, HBO, and NHB trips are shown **Tables 5.1** and **5.2** respectively. The trip rates for CMVEH and TRK (FRT) trips are shown in **Table 5.3**.

Table 5.1: Trip Production Rates

Trip Purpose	HH Size	Vehicle Ownership (Number of Vehicles)			
		0 VEH	1 VEH	2 VEH	3+ Veh
HBW	1 HH	0.2170	0.6509	0.7594	0.9763
	2 HH	0.7594	0.8678	1.4102	1.5187
	3 HH	1.0848	1.3017	2.1696	2.8205
	4 HH	1.0848	1.8441	2.1696	3.1459
	5+ HH	1.0848	1.6272	2.4950	3.5798
HBO	1 HH	1.2279	1.9442	2.0465	2.0465
	2 HH	3.3767	3.6837	3.6837	3.6837
	3 HH	5.2186	6.8558	6.8558	6.8558
	4 HH	8.2883	9.7209	9.7209	9.7209
	5+ HH	10.5395	10.5395	12.3813	15.0418
NHB	1 HH	0.6975	1.3950	1.5942	1.5942
	2 HH	1.6939	2.2917	2.5906	2.6903
	3 HH	1.9928	3.4874	3.8860	4.4838
	4 HH	3.6867	3.8860	5.4802	5.7791
	5+ HH	3.8860	3.8860	5.5799	7.0745

Source: AOMPO TDM, NSI

Table 5.2: Trip Attraction Rates

Trip Purpose	Employment Type							
	RET	RET2	OS	OTH	AMC	MTCUW	SCHATT	OCCDU
HBW	0.8598	0.8598	0.8598	0.8598	0.8598	0.8598	0.0000	0.0000
HBO	1.8128	7.6136	3.1723	0.6345	0.6345	0.6345	0.6046	0.6345
NHB	1.4008	4.7027	1.4008	0.5003	0.5003	0.5003	0.2762	0.6003

Source: AOMPO TDM, NSI

Table 5.3: Commercial Vehicle and Freight Vehicle Trip Rates

Trip Purpose	Employment Type					
	RET	OS	OTH	AMC	MTCUW	OCCDU
CMVEH	0.4542	0.2235	0.2235	0.5678	0.4798	0.1284
FRT	0.1627	0.0394	0.0394	0.2368	0.1770	0.0701

Source: AOMPO TDM, NSI

5.2 Special Generators

A special generator is a land use with unusually low or high trip generation characteristics when compared to the established trip generation rates. For the AOMPO TDM, there were no locations identified as special generators.

5.3 Balancing Productions and Attractions

Productions and attractions are balanced at the study area level for all trip purposes which means that the area-wide trip attractions match the amount of area-wide trip productions. HBW and HBO trips are balanced by holding the productions as a constant since household data is typically considered to be more accurate than employment data. The NHB trips are balanced by holding the attractions as a constant. The trips produced at the households or trip origins must be equal to the total number of trips attracted to the non-home ends or destinations. **Table 5.4** shows the daily trips by trip purpose before and after balancing.

Table 5.4: Balanced Productions and Attractions

Trip Purpose	Before Balancing		After Balancing		% DEV	% Limit
	Production	Attraction	Production	Attraction		
HBW	75,092	75,093	75,092	75,092	0.0%	+/- 10%
HBO	270,329	270,321	270,329	270,329	0.0%	+/- 10%
NHB	155,193	155,189	155,189	155,189	0.0%	+/- 10%
CMVEH	36,413	36,413	36,413	36,413	0.0%	+/- 10%
FRT	12,606	12,606	12,606	12,606	0.0%	+/- 10%

Source: AOMPO TDM, NSI

5.4 Summary

The TDM is calibrated and validated using the following sources:

- *Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee* [2]
- *Travel Model Validation and Reasonableness Checking Manual, 2nd Edition.*[3]

Using the guidelines listed in the above sources, several key statistics for trip generation were monitored and are shown in **Table 5.5**.

Table 5.5: Modeled vs Benchmark Trip Rates

Trip Rate	Modeled	Low Benchmark	High Benchmark
Person Trips per Person*	4.30	3.30	4.00
Person Trips per Household	9.30	8.00	10.0
HBW Person Trips per Employee*	0.86	1.20	1.55
HBW Trips	19.0%	12.0%	24.0%
HBO Trips	56.1%	45.0%	60.0%
NHB Trips	24.9%	20.0%	33.0%

Source: AOMPO TDM, NSI
*Results skewed due to presence of Auburn University

As shown in **Table 5.5**, trip generation statistics are within the allowable limits. No further adjustments were made since the model performed well within all benchmark ranges.

[2] Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee
[3] Travel Model Validation and Reasonableness Checking Manual, 2nd Edition. Travel Model Improvement Program.

6.0 Trip Distribution

The next step in travel demand modeling is the trip distribution process. This function determines the destinations of trips produced in the trip generation model, and conversely, where the attracted trips originated.

6.1 Gravity Model

Many models are available for this process; however, the AOMPO TDM effort used the traditional gravity model.

This model employs two relationships, the first of which is indirect:

The shorter the travel time to the destination zone, the greater the number of trips will be distributed to it from the origin zone.

The second relationship is direct:

The more attractions there are in a destination zone, the more trips will be distributed to it from the origin zone.

The generalized equation for this model is:

$$T_{ij} = \frac{(P_i)(A_j)(F_{ij})}{\sum_{j=1}^{n}(A_j)(F_{ij})(K_{ij})}$$

Where:

T_{ij} = Trips distributed between zones i and j

P_i = Trips produced at zone i

A_j = Trips attracted to zone j

F_{ij} = Relative distribution rate (friction factors or impedance function) reflecting impedance between zone i and zone j

K_{ij} = Calibration parameter.

n = Total number of zones in study area

6.2 Impedance Matrix

The TDM uses a travel time impedance matrix for each zonal pairing within the study area. This matrix traced the shortest free-flow travel time path from zone i (the start of the trip) to zone j (the end of the trip). These values are placed in what is called a skim matrix. Intrazonal trips are unable to build a path for calculation purposes since i and j are the same zone in this case. When this situation occurred, the travel time in the skim matrix was computed by taking half of the average of travel time from zone i to its three closest zones.

6.3 Friction Factors

In a model of this type, friction factors determine the effect that spatial separation has on trip distribution between zones which is the first relationship that was mentioned for the gravity model. These factors measure the probability of trip making at one-minute increments of travel time. Friction factors in the gravity model are an inverse function of travel time, and each unique trip purpose has its own friction factors. This TDM effort uses the gamma function to derive the friction factors. Calibration of a gamma impedance function involves estimating the three parameters of the gamma function; a, b, and c.

$$F_{ij} = (a)(t_{ij}^{b})(exp^{t_{ij}*c})$$

Where: a = Alpha coefficient

b = Beta coefficient

c = Gamma Coefficient

t_{ij} = Impedance or trip length in minutes

This TDM effort used Replica data to calibrate the gamma function parameters. The gamma function parameter values developed for each trip purpose are shown in **Table 6.1**.

Table 6.1: Gamma Function Parameter Values by Trip Purpose

Trip Purpose	a	b	c
HBO	65231.0527	0.8151	0.0859
HBW	4665.0270	0.8187	0.0147
NHB	14814.7845	1.0537	0.0980
CMVEH	1.0000	0.0000	0.1000
EIAUTO	5.8171	-2.1712	0.1481
FRT	1.0000	0.0000	0.0900
EITRK	1.0000	0.0000	0.0507

Source: AOMPO TDM, NSI

6.4 Terminal Times

Terminal times reflect additional travel that is associated with a trip. This travel can be events such as parking or walking to vehicles and/or facilities. This factor was added to the beginning and end of each trip using a terminal time of one minute. This value has been updated for this TDM effort.

6.5 Trip Length Frequency Distribution

As mentioned previously, the gravity model develops friction factors in one minute increments and accommodates various lengths of trips. The average trip lengths obtained from the model are displayed in **Table 6.2**. The average trip lengths that were estimated using National Household Travel Survey (NHTS) data are included in the trip length table for comparison. **Figure 6.1** through **Figure 6.3** show the modeled trip length frequency distribution for HBW, HBO, and NHB trips. These curves were compared to those used in the Replica data and determined to be within an acceptable level of consistency.

Table 6.2: Average Trip Length by Trip Purpose

Trip Purpose	2023 Model Average Trip Length (min)	Low Benchmark Average Trip Length (min)	High Benchmark Average Trip Length (min)
HBW	12.0	12.0	35.0
HBO	10.0	8.0	20.0
NHB	9.5	6.0	19.0

Source: AOMPO TDM, NSI

Figure 6.1: Base Year 2023 Modeled HBW Trip Length Frequency Distribution

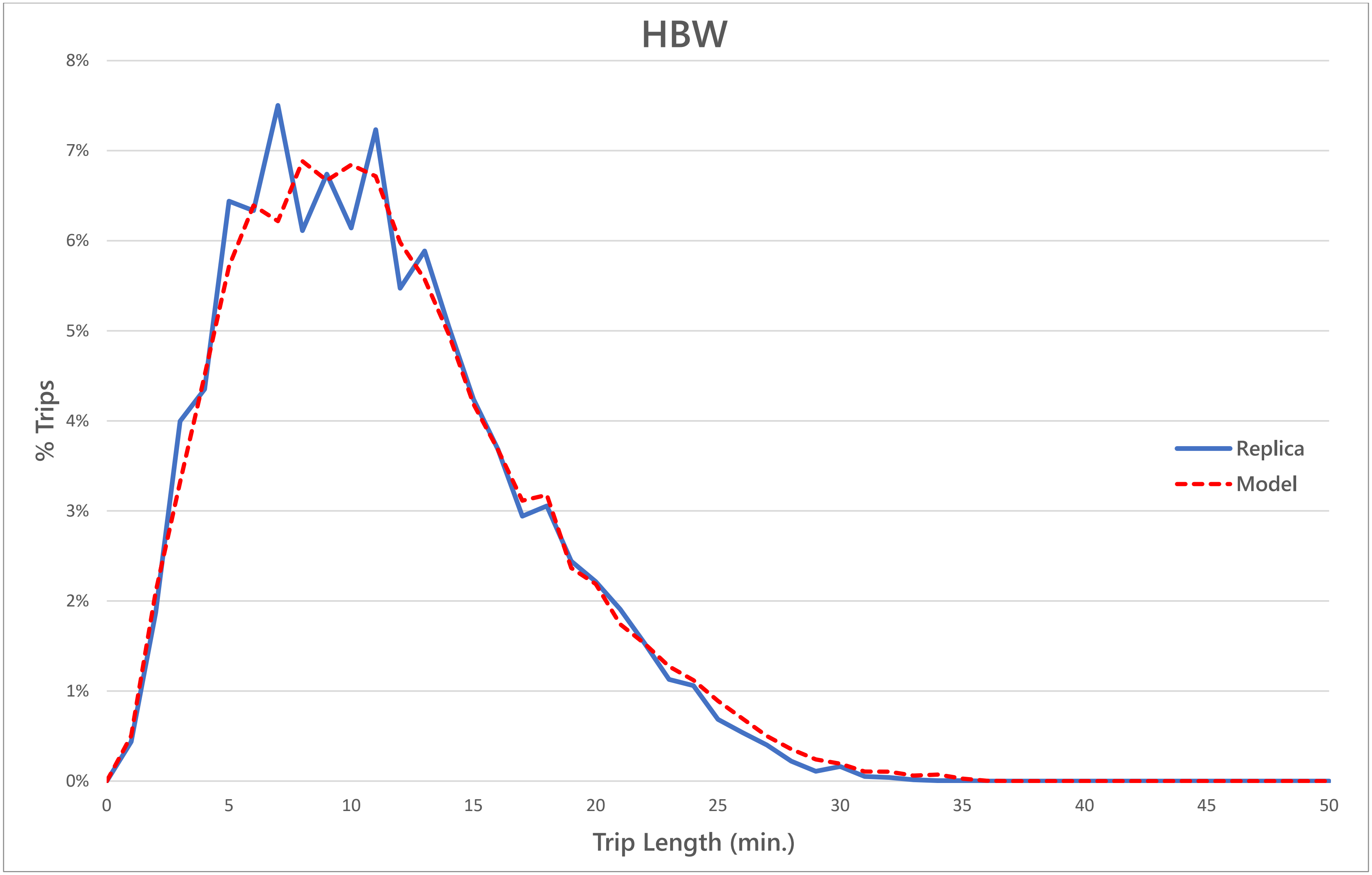


Figure 6.2: Base Year 2023 Modeled HBO Trip Length Frequency Distribution

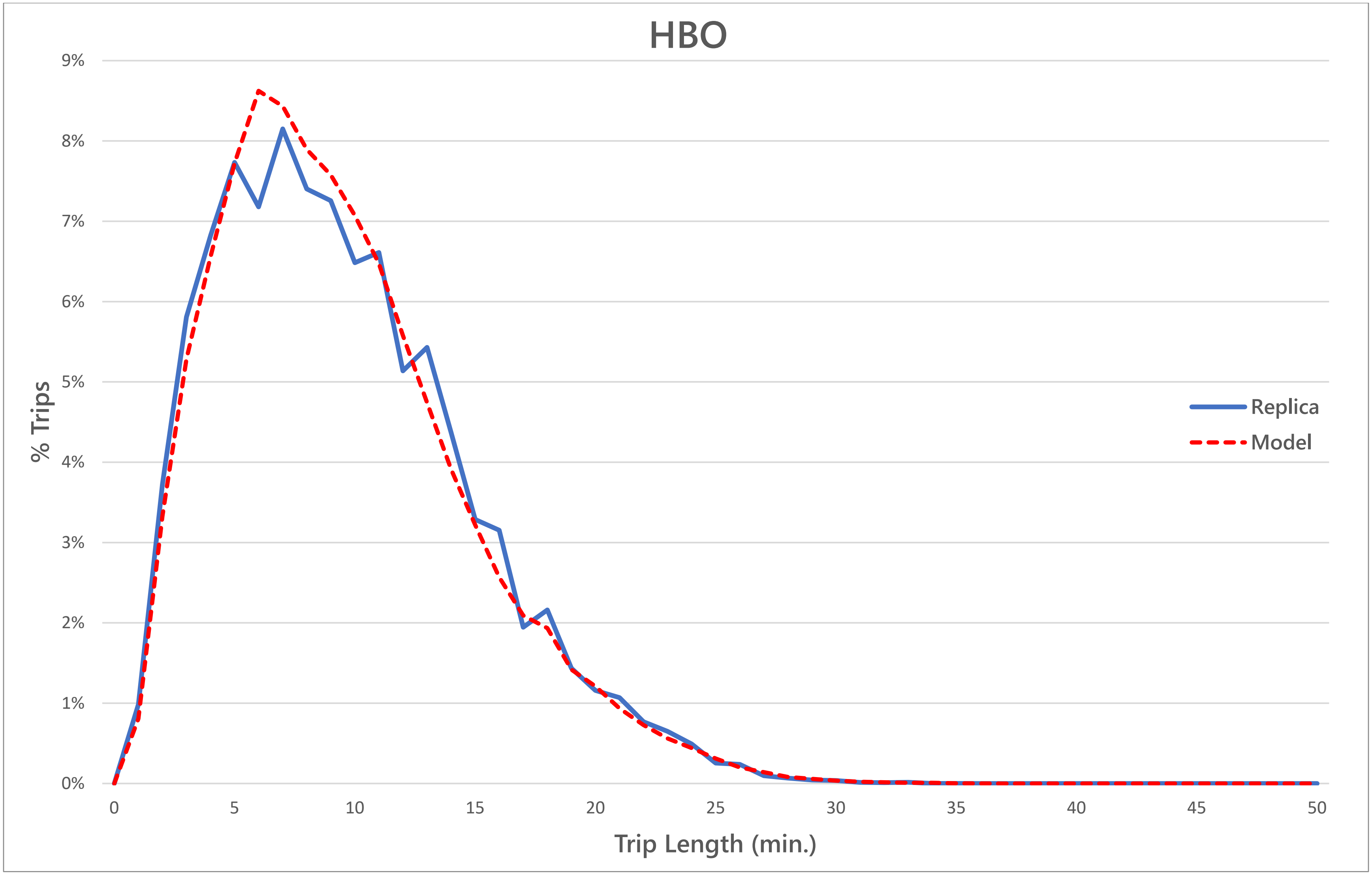
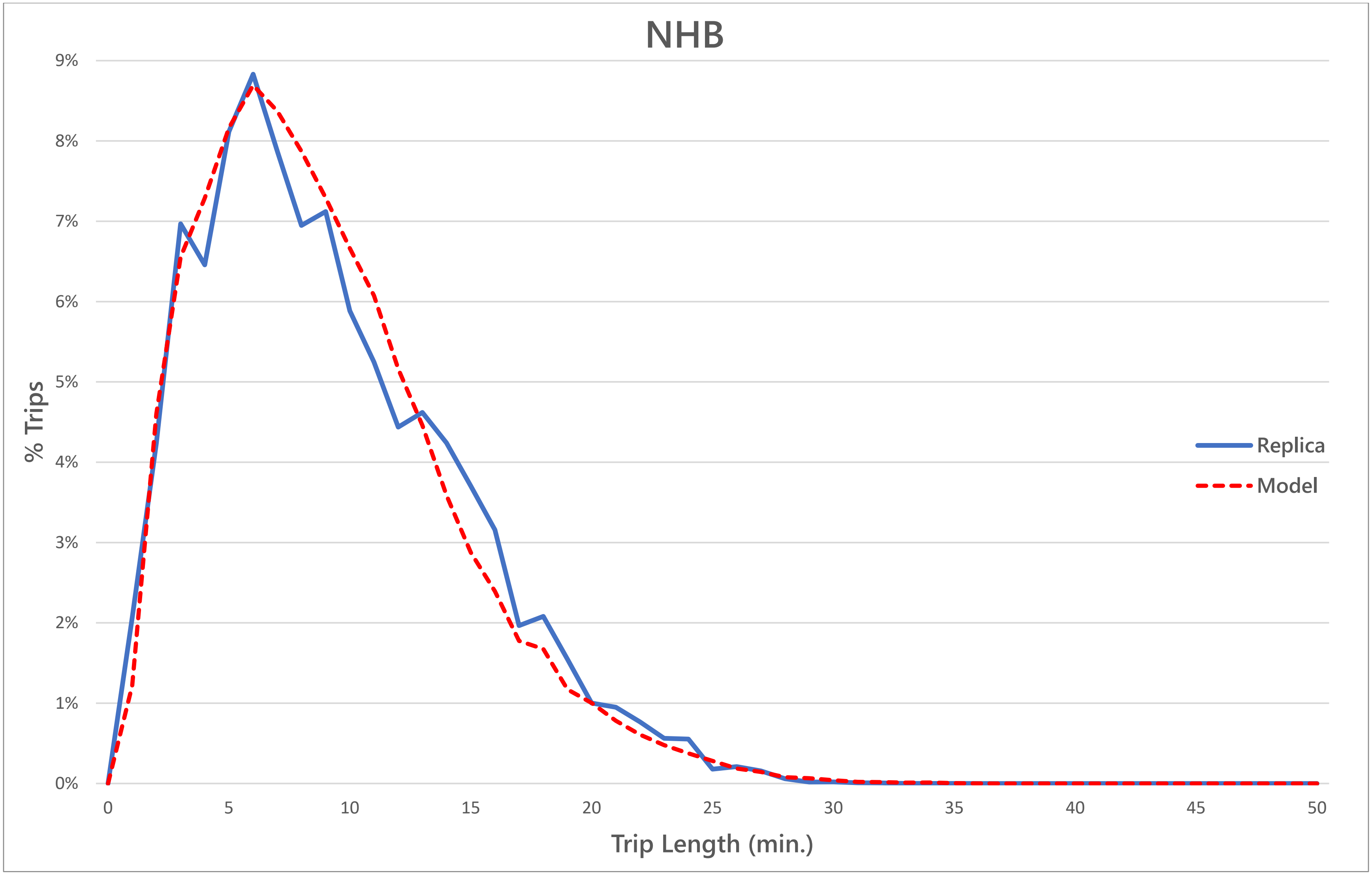


Figure 6.3: Base Year 2023 Modeled NHB Trip Length Frequency Distribution



6.6 Auto Occupancy Rates

The trip rates calculated in the Trip Generation step for HBW, HBO, and NHB trips are in person trips. For the TDM to assign vehicles to the roadway network, the number of trips assigned must be in vehicle trips. This process is done using auto occupancy factors. It divides the amount of person trips by the corresponding occupancy factors shown in **Table 6.3**. The factors used in this TDM update were pulled directly from the NCHRP 716 report.

Table 6.3: Model Auto Occupancy Factors

Trip Purpose	Modeled	Low Benchmark	High Benchmark
HBW	1.10	1.05	1.10
HBO	1.72	1.65	1.95
NHB	1.66	1.60	1.90

Source: NCHRP 716

7.0 Trip Assignment

Trip assignment is the final step in the traditional four-step planning model. Traffic assignment models are used to estimate the traffic flows on a network. The main input to these models is a matrix of flows that indicate the volume of traffic between origin-destination (O-D) pairs. The other inputs to these models are network topology, link characteristics, and link performance functions.

The trips between each O-D pair are loaded onto the network based on the travel time or impedance of the alternative paths that could carry this traffic. The 2050 LRTP model is a user equilibrium model with a generalized cost assignment that uses travel time as the cost.

7.1 BPR Volume-Delay Functions

The TDM link travel time was estimated by the Bureau of Public Roads (BPR) Volume-Delay function. The values that were used in the BPR formula are determined by facility type. The TDM has updated alpha and beta values which are assigned by a roadway's functional classification. The assignment process used in the TDM analyzes link and intersection delay. For segments, as traffic volume increases on a roadway and approaches its maximum capacity, the average speed on the roadway declines. After a point, the roadway speed declines past that of the free flow speed and indicates congestion. The intersection delay is calculated using intersection volume/capacity (VOC) ratios and intersection capacities on the intersection links.

The generalized equation for the BPR formula is:

$$T = T_0 * (1 + \alpha * (\frac{v}{c})^{\beta})$$

Where: T = Congested travel time

T_0 = Free flow travel time

v = Assigned link volume

c = Capacity

α, β = BRP coefficients

This information allows for the calculation of the roadway's peak hour travel:

Peak Hour Travel Speed = (Free Flow Speed)/ $(1 + \alpha * (\frac{v}{c})^{\beta}$

The BPR coefficients used in the TDM were derived from NCHRP 365 and are consistent with LOS D capacity factors shown in **Figure 3.2**. The BPR coefficients are shown in **Table 7.1**.

Table 7.1: BPR Volume-Delay Function Parameters

Model Functional Class	Alpha	Beta
Rural Interstate	0.83	5.50
Rural Principal Arterial	0.71	2.10
Rural Minor Arterial	0.71	2.10
Rural Major Collector	0.60	1.60
Rural Minor Collector	0.60	1.60
Rural Local	0.60	1.60
Rural Other	0.60	1.60
Rural On/Off Ramp	0.71	2.10
Urban Interstate	0.83	5.50
Urban Expressway	0.71	2.10
Urban Principal Arterial	0.71	2.10
Urban Minor Arterial	0.71	2.10
Urban Collector	0.60	1.60
Urban Local	0.60	1.60
Urban Other	0.60	1.60
Urban On/Off Ramp	0.71	2.10
Centroid Connector	0.15	4.00

Source: AOMPO TDM, NSI

8.0 Model Validation

The purpose of model validation is to make the adjustments necessary to replicate the base-year traffic conditions as closely as possible. In practice, this means making the link assignment volumes approximate the traffic estimates, based on actual counts, within acceptable limits of deviation. Generally speaking, the lower the volume, the greater the relative deviation that is acceptable. Conversely, the greater the amount of traffic, the greater the degree of accuracy required. The ultimate purpose of the model is to determine whether additional vehicular capacity will be needed on any given roadway at a designated future date.

Where existing volumes are low, the model assignment may deviate from actual conditions by 40 or 50 percent without affecting the projected need for additional capacity. On the other hand, in the case of a heavily traveled interstate route, a deviation of 20 percent may be significant (i.e., alter the projection of required capacity). The validation process is intended to verify that the model is performing within the limits that define acceptable ranges of deviation from observed "real-world" values.

As stated previously, the *Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee* and the *Travel Model Validation and Reasonableness Checking Manual, 2nd Edition*, were used as guidelines for the validation of TDMs. The following criteria were used to validate the AOMPO TDM:

- Vehicle Miles Traveled (VMT) by Region and Facility Type
- Percent Root Mean Square Error (RMSE) by Functional Class
- Percent RMSE by Volume Group
- Percent Error/Deviation by Roadway Facility
- Coefficient of Determination (R^2)
- Screenlines and Cutlines
- Cordon Lines

8.1 VMT by Region and Facility Type

The VMT of a roadway link is calculated by multiplying the vehicle volume on a link by its length in miles. The validation of the TDM looks at the VMT of the entire study area as well as the individual functional classification of roadways in the study area that are classified as collectors or higher. **Table 8.1** displays the VMT of the study area.

Table 8.1: VMT by Functional Classification

Functional Classification	Counts VMT	Model VMT	Percent Deviation	Percent Limit
Interstate	678,370	734,635	8.3%	+/- 28-27
Major Arterial/ Expressway	303,797	299,492	-1.4%	+/- 37-43
Minor Arterials	381,841	353,154	-7.5%	+/- 25-28
Collectors	230,019	238,679	3.8%	+/- 12-15
Local/Centroid Connectors	40,084	39,982	-0.3%	N/A
Regional	1,669,511	1,705,996	2.2%	N/A

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee, ALDOT, AOMPO TDM, NSI, 2023

8.2 Percent RMSE

The RMSE measure was chosen for the following reason: when comparing model flows versus counts, sometimes a straight aggregate sum by link group can be misleading. The sum of all traffic counts for a particular link group may be close to the sum of the corresponding traffic flows, but individual link flows may still be very different than their corresponding link count. However, the RMSE statistic does not convey information about the magnitude of the error relative to that of the counts. Therefore, the Percent Root Mean Square Error (Percent RMSE or % RMSE) is often computed. This measure expresses the RMSE as a percentage of the average count value. The Percent RMSE is defined below:

$$\%RMSE = \frac{\sqrt{\sum_j (Model_j - Count_j)^2 / (Numberofcounts)}}{\left(\sum_j Count_j \middle/ Numberofcounts\right)} * 100$$

Validation results by ADT group and functional class are shown in **Table 8.2** and **Table 8.3** respectively.

Table 8.2: RMSE by ADT Group

ADT Range	Number of Observations	Total Count[1]	Total Model Volume[2]	% RMSE	% RMSE Limit[3]
ADT<5,000	251	563,718	634,398	68.3	45.0-100
5,000 <= ADT < 10,000	147	1,068,227	978,392	29.4	35.0-45.0
10,000 < =ADT < 15,000	62	748,428	694,468	20.9	27.0-35.0
15,000 < =ADT < 20,000	45	787,249	729,538	14.3	25.0-30.0
20,000 < =ADT < 30,000	45	1,084,662	1,101,044	16.3	15.0-27.0
30,000 < =ADT <50,000	4	140,401	132,337	9.2	15.0-25.0
Areawide	554	4,392,685	4,270,176	27.7	35.0-45.0

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee, ALDOT, AOMPO TDM, NSI, 2023

Table 8.3: RMSE by Roadway Functional Class

Functional Class	Number of Observations	Total Count[1]	Total Model Volume[2]	% RMSE	% RMSE Limit[3]
Interstate	16	372,304	403,032	10.7	20
Major Arterial/ Expressway	70	1,212,305	1,209,680	17.6	30.0-35.0
Minor Arterial	185	1,795,626	1,640,680	25.4	40.0-50.0
Collector	218	713,568	697,873	55.5	60.0-70.0
Areawide	554	4,392,685	4,270,176	27.7	35.0-45.0

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee, ALDOT, AOMPO TDM, NSI, 2023

(1) Total Count represents the sum of average daily traffic estimates for all ALDOT count locations (area wide), all count locations on principal arterials, all locations on minor arterials, all on major/minor collectors.

(2) Total Model Volume is the sum of model-generated traffic volumes for all network links associated with ALDOT count locations (area wide), all links associated with count locations on principal arterials, all links associated with locations on minor arterials, and all links associated with count locations on collectors.

(3) % RMSE Limit is the maximum acceptable magnitude of the error relative to that of the counts conducted by ALDOT.

8.3 Percent Error

The next measure of model validation is the percent error, or percent deviation, of the model's assigned traffic volumes to the observed traffic counts. **Table 8.4** and **Table 8.5** display the validation results by ADT group and by facility type respectively.

Table 8.4: Percent Deviation by ADT Group

ADT Range	Number of Observations	Total Count[1]	Total Model Volume[2]	% Dev	% Dev Limit[3]
ADT<1,000	66	37,197	49,196	32.3	+/-200.0
1,000 < =ADT < 2,500	72	119,915	135,594	13.1	+/-100.0
2,500 <= ADT < 5,000	113	406,606	449,608	10.6	+/-50.0
5,000 <= ADT < 10,000	147	1,068,227	978,392	-8.4	+/-25.0
10,000 < =ADT <25,000	136	2,182,357	2,103,037	-3.6	+/-20.0
25,000 < =ADT < 50,000	20	578,383	554,349	-4.2	+/-15.0
Areawide	554	4,392,685	4,270,176	-2.8	+/-5.0

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee, ALDOT, AOMPO TDM NSI, 2023

Table 8.5: Percent Deviation by Facility Type

Facility Type	Number of Observations	Total Count[1]	Total Model Volume[2]	% Dev	% Dev Limit[3]
Interstate*	16	372,304	403,032	8.3	+/-7
Major Arterial/ Expressway	70	1,212,305	1,209,680	-0.2	+/-10
Minor Arterial	185	1,795,626	1,640,680	-8.6	+/-15
Collector	218	713,568	697,873	-2.2	+/-25
Areawide	554	4,392,685	4,270,176	-2.8	+/-5

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee, ALDOT, AOMPO TDM NSI, 2023

(1) Total Count represents the sum of average daily traffic estimates for all ALDOT count locations (area wide), all count locations on principal arterials, all locations on minor arterials, all on major/minor collectors.

(2) Total Model Volume is the sum of model-generated traffic volumes for all network links associated with ALDOT count locations (area wide), all links associated with count locations on principal arterials, all links associated with locations on minor arterials, and all links associated with count locations on collectors.

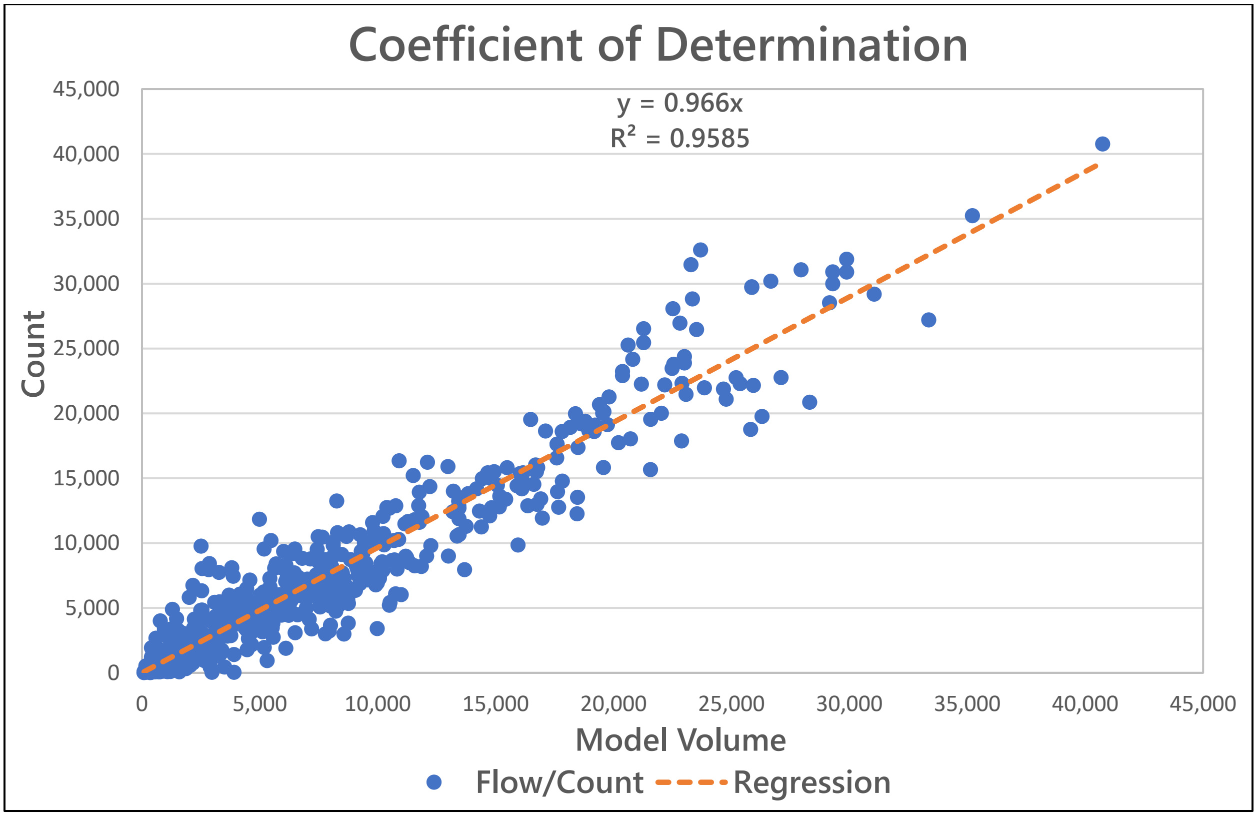
(3) % Dev Limit is the maximum acceptable plus/minus percentage deviation from estimated base-year (2023) average daily traffic (ADT) based on counts conducted by ALDOT.

*Results skewed due to presence of Auburn University

8.4 Coefficient of Determination

The coefficient of determination (R^2) provides a correlation between the observed traffic volumes from ALDOT and the estimated TDM volumes. The TNMUG guidelines recommend a minimum R^2 of 0.88. The areawide coefficient of this TDM effort was 0.96 and a scatter plot of the results is shown in **Figure 8.1**.

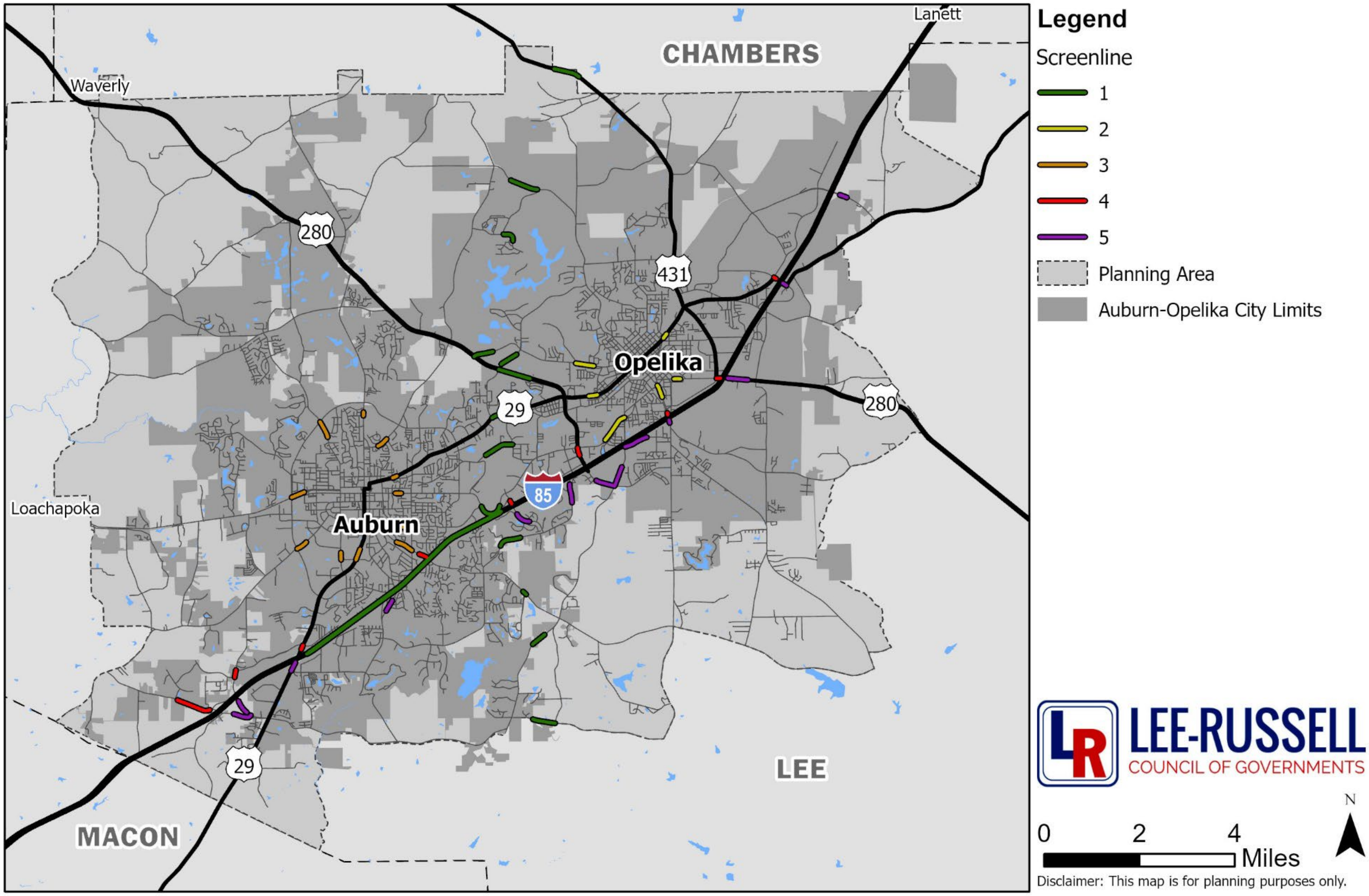
Figure 8.1: Base Year 2023 Modeled Volume vs Traffic Count Plot



8.5 Screenlines, Cutlines, and Cordon Lines

In travel demand modeling, screenlines and cutlines are used to assess how well the model replicates major trip movements and travel between different subareas of the study area. Screenlines often go from boundary cordon to boundary cordon within a study area and are usually a significant physical feature within the study area such as rail lines, rivers, etc. Cutlines extend across corridors and contain multiple facilities and assist with validation of corridor flows within the TDM. **Figure 8.2** shows the screenlines and cutlines used in the model validation, while **Table 8.6** displays the results of the screenline analysis.

Figure 8.2: LRTP 2050 Screenlines



Source: AOMPO TDM, NSI

Table 8.6: Screenline and Cutline Analysis

Line Number	Type	Number of Observations	Total Count[1]	Total Model Volume[2]	% Dev	Allowable % Dev
1	Screenline	15	161,805	171,416	5.9	+/-10.0
2	Screenline	7	86,583	87,715	1.3	+/-10.0
3	Screenline	11	113,052	113,106	0.0	+/-10.0
4	Screenline	9	149,585	155,991	4.3	+/-10.0
5	Screenline	13	126,859	127,288	0.3	+/-10.0

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee, ALDOT, AOMPO TDM, NSI, 2023
(1) Total Count represents the sum of average daily traffic estimates for all ALDOT count locations (area wide), all count locations on principal arterials, all locations on minor arterials, all on major/minor collectors.
(2) Total Model Volume is the sum of model-generated traffic volumes for all network links associated with ALDOT count locations (area wide), all links associated with count locations on principal arterials, all links associated with locations on minor arterials, and all links associated with count locations on collectors.

An analysis of the study area boundary's cordon lines was also conducted to determine if the external station TDM volumes matched the volumes of the traffic counts. Based on the TNMUG guidance, all external station link model volumes should be within +/- one percent of the observed traffic counts. The results of the cordon analysis are shown in **Table 8.7**.

Table 8.7: Cordon Analysis

External Station	Description	Count Volume	Model Volume	Model/Count
401	US 431	3,432	3,432	1.0
402	CR-173	178	178	1.0
403	CR-389	497	497	1.0
404	CR-174	300	300	1.0
405	I-85	40,746	40,746	1.0
406	US 29	6,267	6,267	1.0
407	CR-252	600	600	1.0
408	CR-182	700	700	1.0

External Station	Description	Count Volume	Model Volume	Model/Count
409	CR-158	1,287	1,287	1.0
410	US 280	22,177	22,177	1.0
411	CR-151	217	217	1.0
412	CR-148	454	454	1.0
413	CR-145	653	653	1.0
414	SR-169	5,600	5,600	1.0
415	CR-166	2,816	2,816	1.0
416	CR-400	3,079	3,079	1.0
417	SR-51 (Marvyn Pkwy)	6,100	6,100	1.0
418	CR-54	1,005	1,005	1.0
419	CR-159	571	571	1.0
420	US 29	4,800	4,800	1.0
421	I-85	35,225	35,225	1.0
422	CR-137	1,475	1,475	1.0
423	CR-61	1,200	1,200	1.0
424	CR-61	900	900	1.0
425	CR-393	280	280	1.0
426	SR-14	5,305	5,305	1.0
427	CR-188	1,056	1,056	1.0
428	CR-72	2,020	2,020	1.0
429	US 280	13,475	13,475	1.0
430	Patrick St	93	93	1.0
431	SR-147	2,790	2,790	1.0

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee, ALDOT, AOMPO TDM, NSI, 2023

The validation effort concluded that the AOMPO study area travel demand forecasting model performs within the established limits of acceptable deviation from base-year estimated volumes.

9.0 Future Year Model Development

Future year models were developed to forecast traffic that the study area will experience based on its anticipated growth. These models used forecasted socioeconomic data, external travel, and special generator data. Forecast models also require updates to the roadway network based on projects that are expected to occur or have funding allocated to implement them in the near future.

9.1 Future Year Socioeconomic Data Development

To adequately forecast future transportation system needs, future projections of demographic variables were developed for each Traffic Analysis Zone (TAZ).

Population and Employment Growth

County-level growth rates and study area-level population and employment control totals for the year 2050 were developed in consultation with AOMPO. These forecasts were developed based on a comparison of the previous LRTP, historical trends, state projections, and third-party projections to determine the potential growth rates for the planning area. The growth rates that were determined to be acceptable are shown in **Table 9.1**

Table 9.1: Population and Employment Growth Rates

Source	Forecast Population Annual Growth Rates	Forecast Employment Annual Growth Rates
Woods & Poole (W&P)	0.97%	1.39 %

Source: AOMPO TDM, NSI

Each of the growth rates were applied to the base year population and employment to develop year 2050 data. It was determined that the most reasonable population and employment estimates came from the Woods & Poole projections. Interim control totals were derived using growth rates from the same data sources to determine Year 2030 and Year 2040 control totals. The interim and final horizon year control totals are displayed in **Table 9.2**.

Table 9.2: Planning Area Population and Employment Control Totals

Population					
Region	Year				Total Change in Persons
	2023	2030	2040	2050	
Lee County	183,215	196,091	216,070	238,085	54,870
AOMPO	122,014	130,589	143,895	158,556	36,541
Employment					
Region	Year				Total Change in Employees
	2023	2030	2040	2050	
Lee County	95,471	105,181	120,790	138,715	43,244
AOMPO	87,338	96,221	110,500	126,898	39,560

Source: AOMPO TDM, NSI

Using these control totals, both population and employment growth were sub-allocated to each TAZ in the travel demand model. **Figure 9.1** displays the total population change by TAZ, while **Figure 9.2** displays the percent change of population. **Figure 9.3** displays the total employment change by TAZ, while **Figure 9.4** displays the percent change of employment.

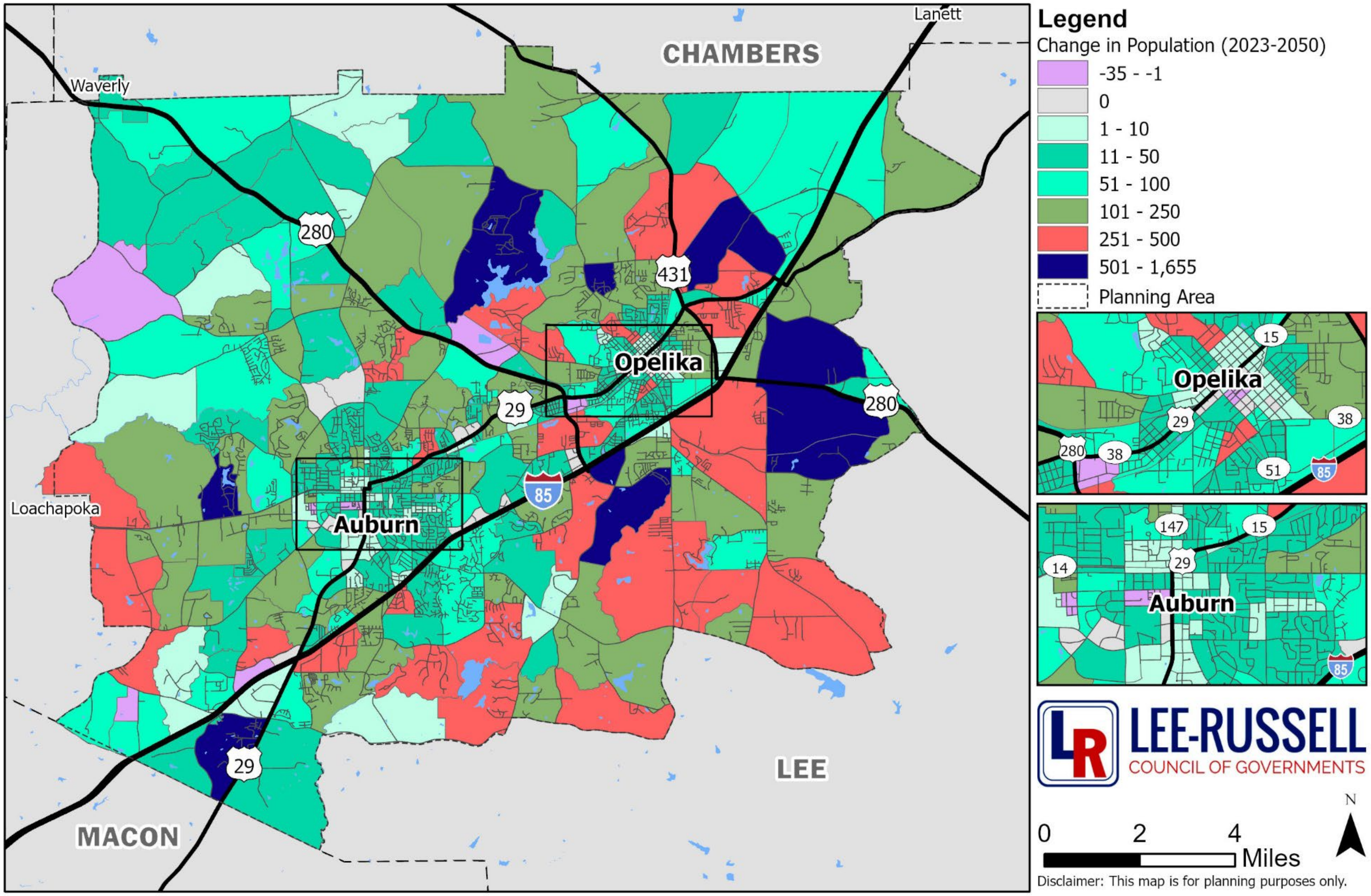
The following process was used:

- Growth that has occurred since the base year was added based upon local and MPO staff knowledge of recent or approved developments.
- The remaining available growth was allocated through 2050.
- Since the new control total resulted in more employment than the 2045 LRTP, growth to the remaining TAZs was proportionately allocated.
- Some growth was "moved" and instead allocated to nearby zones that had not previously received it to produce more reasonable results.
- After approval of the year 2050 TAZ data, data for years 2030 and 2040 were created.

School Enrollment Growth

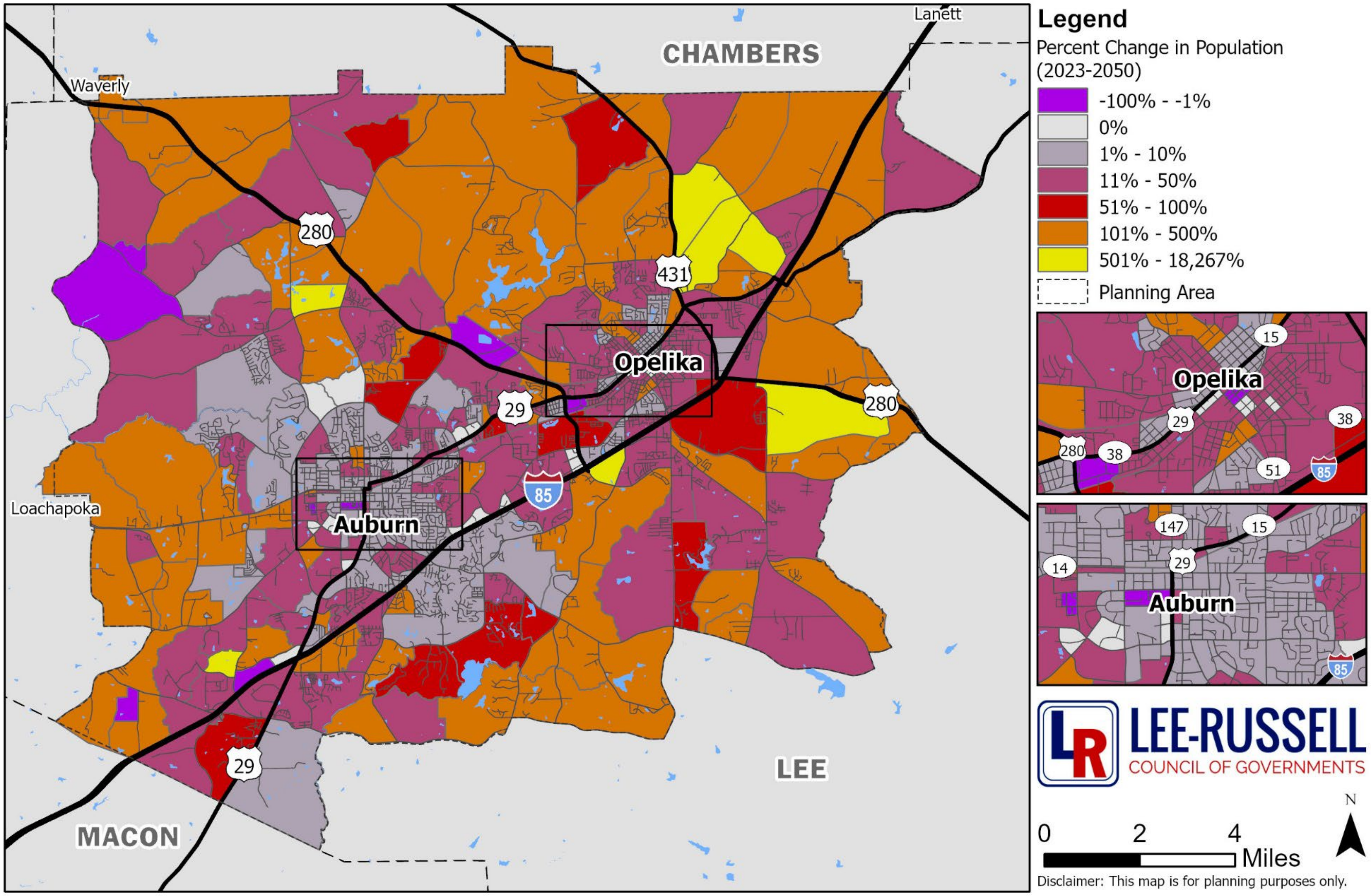
School enrollment was projected to grow at the same rate as the total population until it reached the maximum school enrollment established by the Lee County School System.

Figure 9.1: Population Growth, 2023-2050



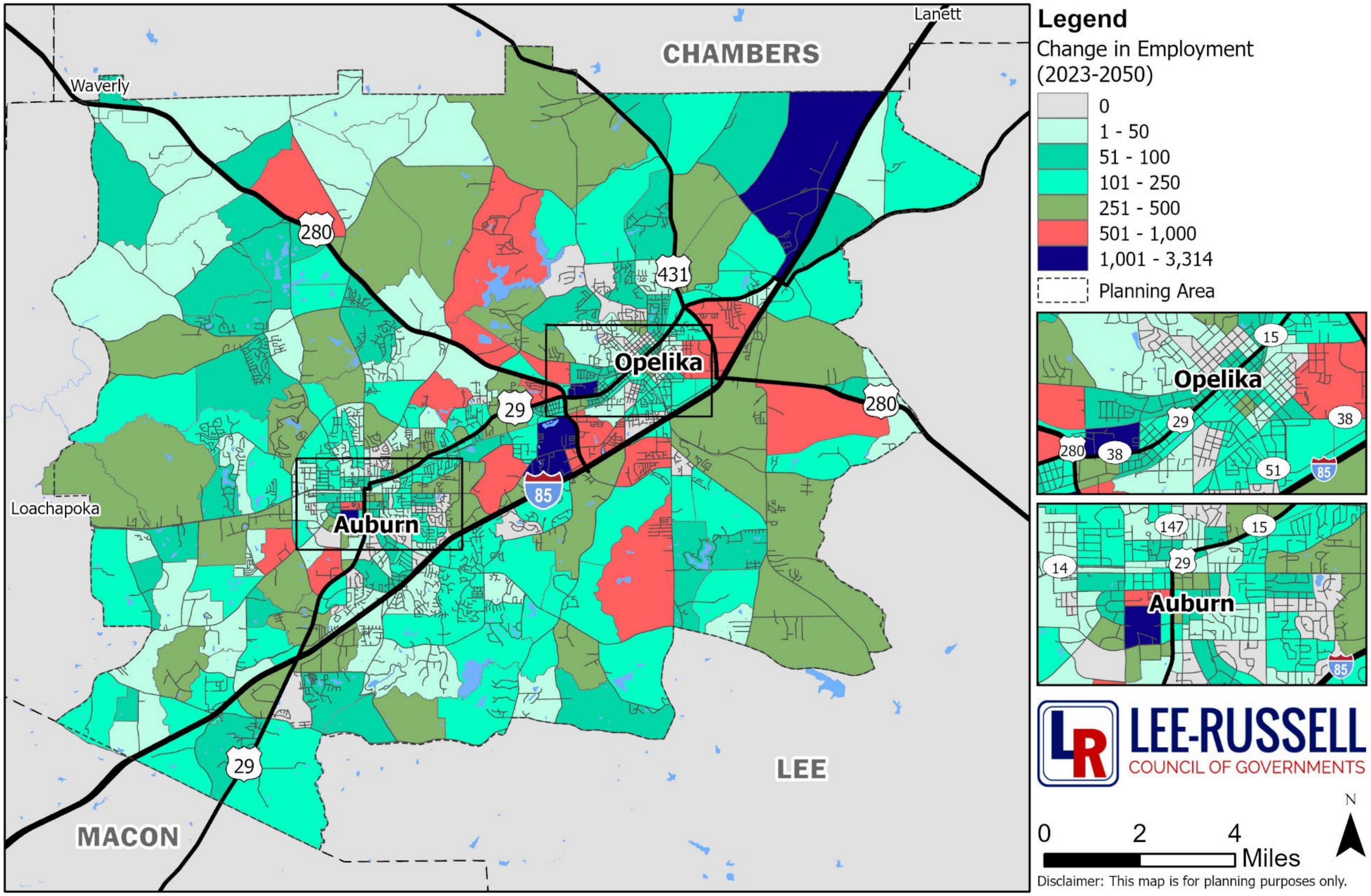
Source: AOMPO TDM, NSI

Figure 9.2: Percent Change in Population, 2023-2050



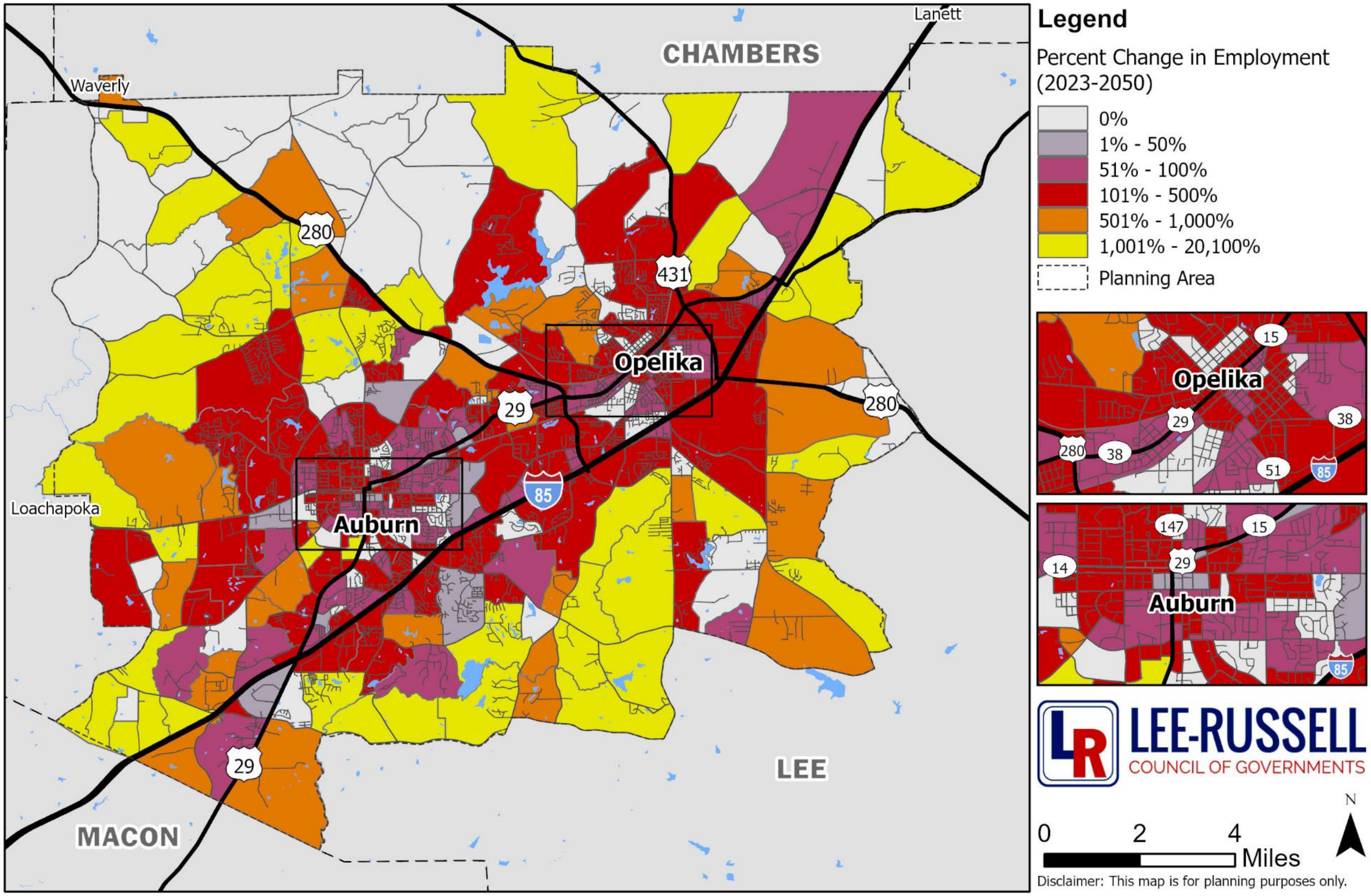
Source: AOMPO TDM, NSI

Figure 9.3: Employment Growth, 2023-2050



Source: AOMPO TDM, NSI

Figure 9.4: Percent Change in Employment, 2023-2050



Source: AOMPO TDM, NSI

9.2 Existing Plus Committed (E+C) Network

The base year network was defined as the street and highway system that existed in year 2023. Once the base year network was calibrated, the E+C network was developed. This network included committed projects.

Committed projects are improvements which meet the following criteria:

- construction was either completed or begun since 2023,
- a contract for construction has been awarded,
- the project has completed the National Environmental Policy Act (NEPA) phase, or
- the project has funding for right-of-way and/or construction programmed in the MPO's Transportation Improvement Program.

Committed projects were added to the base network using the following procedure:

- New routes were coded with the proposed number of lanes and with the posted speed and volume-delay function attributes that reflect the project's functional classification.
- Widened roadways were changed to update the number of lanes in each direction as well as the lane configuration field required by the network.
- All E+C projects were flagged in the 'PROJECT_EC' field using a unique project ID.

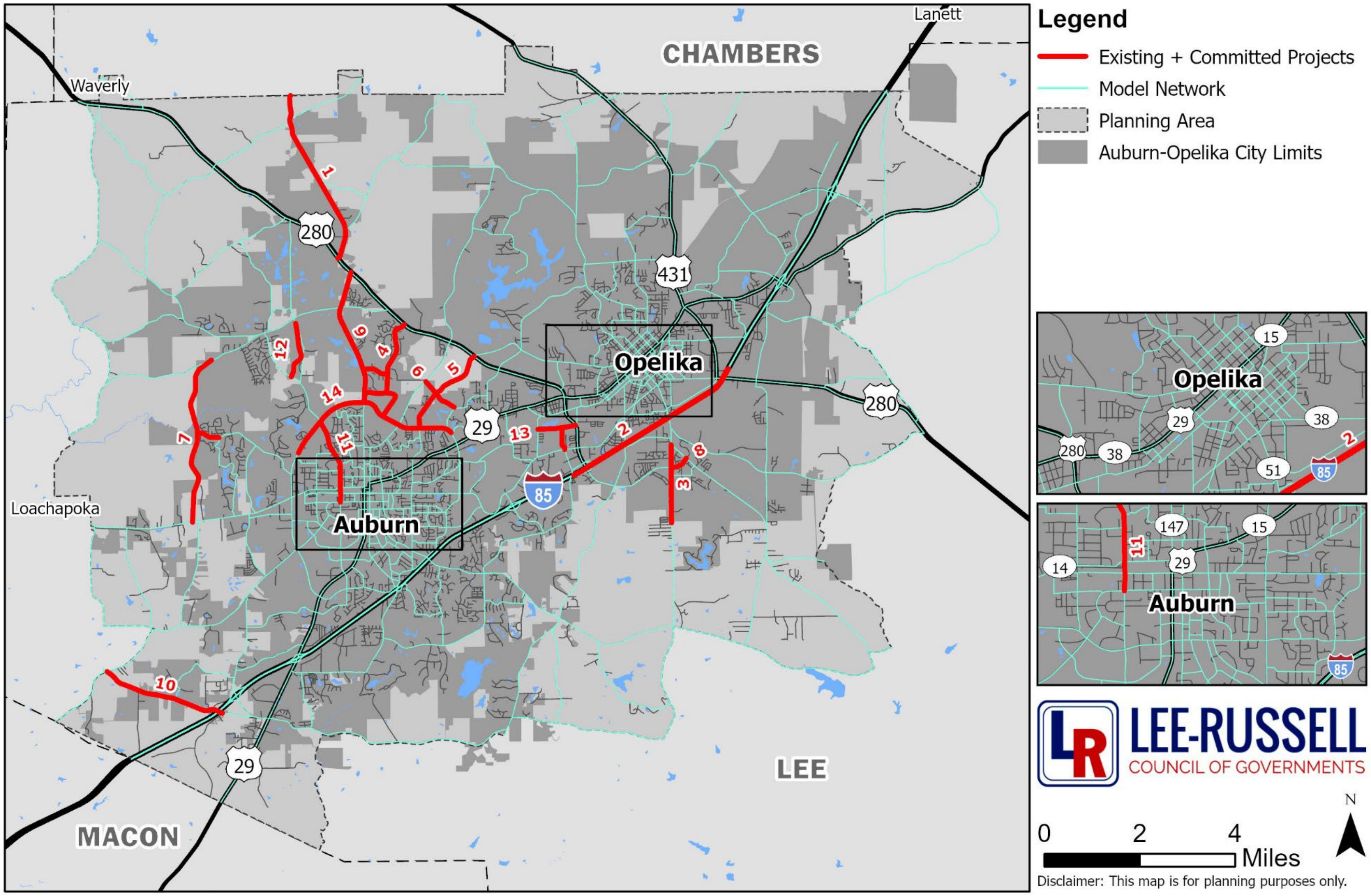
The committed projects are listed in **Table 9.3** and shown in **Figure 9.5**.

Table 9.3: Existing + Committed Projects

Project ID	Sponsor/ Jurisdiction	Roadway	Location	Improvement	Opening Stage Year
1	ALDOT	SR-147	US 280 to Chambers County Line	Resurfacing and shoulder widening	2030
2	ALDOT	I-85	US 280 west to US 280 east	Widen from 4 lanes to 6 lanes	2030
3	City of Opelika	Marvyn Pkwy (SR-51)	Crawford Rd (SR-169) to the southern city limits	Widen from 2 lanes to 3 lanes (CTL)	2030
4	City of Auburn	Watercrest Dr Extension	E University Dr to Cary Creek Pkwy	New 2-lane roadway	2030
5	City of Auburn	Dean Rd Extension	Sandstone Ln to Birmingham Hwy (US-280)	New 3-lane roadway	2030
6	City of Auburn	Academy Dr Extension	Gatewood Dr to Shelton Mill Rd (CR-97)	New 2-lane roadway	2030
7	City of Auburn	Outer Loop - Segment 2/3	Mrs. James Rd (CR-81) to Martin Luther King Dr (SR-14)	New 2-lane roadway	2030
8	City of Opelika	Gateway Dr Extension	Marvyn Pkwy (SR-51) to Crawford Rd (SR-169)	New 2-lane roadway	2030
9	ALDOT	N College St (SR-147)	Shug Jordan Pkwy/E University Dr (SR-267) to US-280	Widen from 2 lanes to 4 lanes	2030
10	City of Opelika	CR-10	CR-137 (Wire Rd) to Cox Rd	Widen from 2 lanes to 3 lanes (CTL) and resurfacing	2030
11	Auburn	N Donahue Dr	W Magnolia Ave to Shug Jordan Pkwy	Widening, Add Bike Lane, Add Sidewalks	2030
12	City of Auburn	James Burt Pkwy	N Donahue Dr to Miracle Rd	New 2-lane roadway	2030
13	City of Opelika	Thomason Dr Ext (Veterans Pkwy Ext Phase 1)	Cunningham Dr to Gateway Dr (US-280); Center Hill Dr to New Roadway	New 2-lane roadway	2030
14	City of Auburn	Shug Jordan Pkwy/ University Dr	Richland Rd to Opelika Rd	Center turn lane and turn lanes	2030

Source: AOMPO TDM

Figure 9.5: Existing + Committed Projects



Source: AOMPO TDM, NSI

9.3 External Station Growth

The base year traffic counts at each external station were projected to 2030, 2040, and 2050 using growth factors developed based on historic traffic counts at the external stations. Development of the growth rates used the following methodology:

- Current ADT counts were used at the external stations as well as historical ADT counts to determine the six-year growth rate and three-year growth rate of traffic at each external station.
- The average of the growth rates was obtained to establish that rate as the initial external station growth rate.
- If the external station rate exceeded three percent annually, the growth rate was adjusted to three percent.
  - External station growth above three percent annually is often indicative of short-term explosive growth due to major developments or temporary changes in traffic patterns caused by construction.
  - These growth rates are generally not sustainable in the long-term and often produce unreasonable results unless there is a known major development or roadway project expected in the future.
  - These external stations have no known major developments or roadway projects, therefore, annual growth rates have been capped to three percent.
- If the external station growth rate was less than one percent, including negative growth rates, the external growth rate was adjusted to one percent.
- For some stations, the average annual growth rate produced unrealistic results or reflected recent explosive growth that is not expected to continue into the future.
  - Stations where this situation occurred had the growth rate adjusted to reflect more reasonable expected growth.

The final forecast growth rates for each external station and comparison of external travel forecast for the base year and target years is shown in **Table 9.4**.

The total traffic at each station was divided into EI and EE trips with the assumption that there would not be a significant change in the distribution from the base year. In addition, both EI and EE forecast trips were also separated into auto and truck trips.

Table 9.4: External Station Forecast Growth

Station ID	Station Description	Forecast Growth Rate	2023 Volume	2030 Volume	2040 Volume	2050 Volume
401	US 431	1.5%	3,432	3,792	4,307	4,822
402	CR-173	1.0%	178	190	208	226
403	CR-389	3.0%	497	601	750	900
404	CR-174	1.0%	300	321	351	381
405	I-85	1.5%	40,746	45,024	51,136	57,248
406	US 29	1.0%	6,267	6,706	7,332	7,959
407	CR-252	1.0%	600	642	702	762
408	CR-182	1.0%	700	749	819	889
409	CR-158	1.0%	1,287	1,377	1,506	1,634
410	US 280	1.5%	22,177	24,506	27,832	31,159
411	CR-151	1.0%	217	232	254	276
412	CR-148	1.0%	454	486	531	577
413	CR-145	3.0%	653	790	986	1,182
414	SR-169	3.0%	5,600	6,776	8,456	10,136
415	CR-166	1.0%	2,816	3,013	3,295	3,576
416	CR-400	3.0%	3,079	3,726	4,649	5,573
417	SR-51 (Marvyn Pkwy)	2.5%	6,100	7,168	8,693	10,218
418	CR-54	2.5%	1,005	1,181	1,432	1,683
419	CR-159	1.0%	571	611	668	725
420	US 29	1.0%	4,800	5,136	5,616	6,096
421	I-85	1.5%	35,225	38,924	44,207	49,491
422	CR-137	1.0%	1,475	1,578	1,726	1,873
423	CR-61	1.0%	1,200	1,284	1,404	1,524
424	CR-61	1.0%	900	963	1,053	1,143
425	CR-393	1.0%	280	300	328	356
426	SR-14	1.0%	5,305	5,676	6,207	6,737
427	CR-188	3.0%	1,056	1,278	1,595	1,911
428	CR-72	1.5%	2,020	2,232	2,535	2,838
429	US 280	1.0%	13,475	14,418	15,766	17,113
430	Patrick St	3.0%	93	113	140	168
431	SR-147	1.0%	2,790	2,985	3,264	3,543

Source: AOMPO TDM, NSI

9.4 Future Year Model Runs

The TDM was used to forecast traffic for the future years using the E+C network and forecast socioeconomic, external station, and special generator data. Interpolation was used where necessary to obtain a future year scenario that occurred between the base year (2023), interim years (2030 and 2040), and the horizon year (2050).