TECHNICAL REPORT 1

Transportation Modeling and Forecasting

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1.0 Introduction and Model Overview

1.1 Introduction

This report includes a description of the procedures used in developing the updated demographics and travel estimates used in the 2045 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. This report does not include how to operate the model.

1.2 Model Overview

The AOMPO Travel Demand Model (TDM) is being updated for use in the MPO's new 2045 LRTP. The new TDM is an update of the model used in the previous LRTP. The updated model was calibrated and validated to meet the requirements established by the Federal Highway Administration (FHWA) as described in the latest *Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee*[1].

The updated TDM uses a 2015 base year. Additional updates to the TDM include updated/revised:

- socioeconomic data
- turn penalties
- time penalties
- external trip data

[1] http://tnmug.utk.edu/wp-content/uploads/sites/47/2017/06/MinimumTravelDemandModel2016.pdf

Introduction and Model Overview

The AOMPO 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 the Cube VOYAGER forecasting software.

2.0 Traffic Analysis Zones and Socioeconomic Data

2.1 Study Area and Traffic Analysis Zones

The accuracy necessary for generating trips from planning data requires it to be aggregated by small geographic areas. These areas are called Traffic Analysis Zones (TAZs).

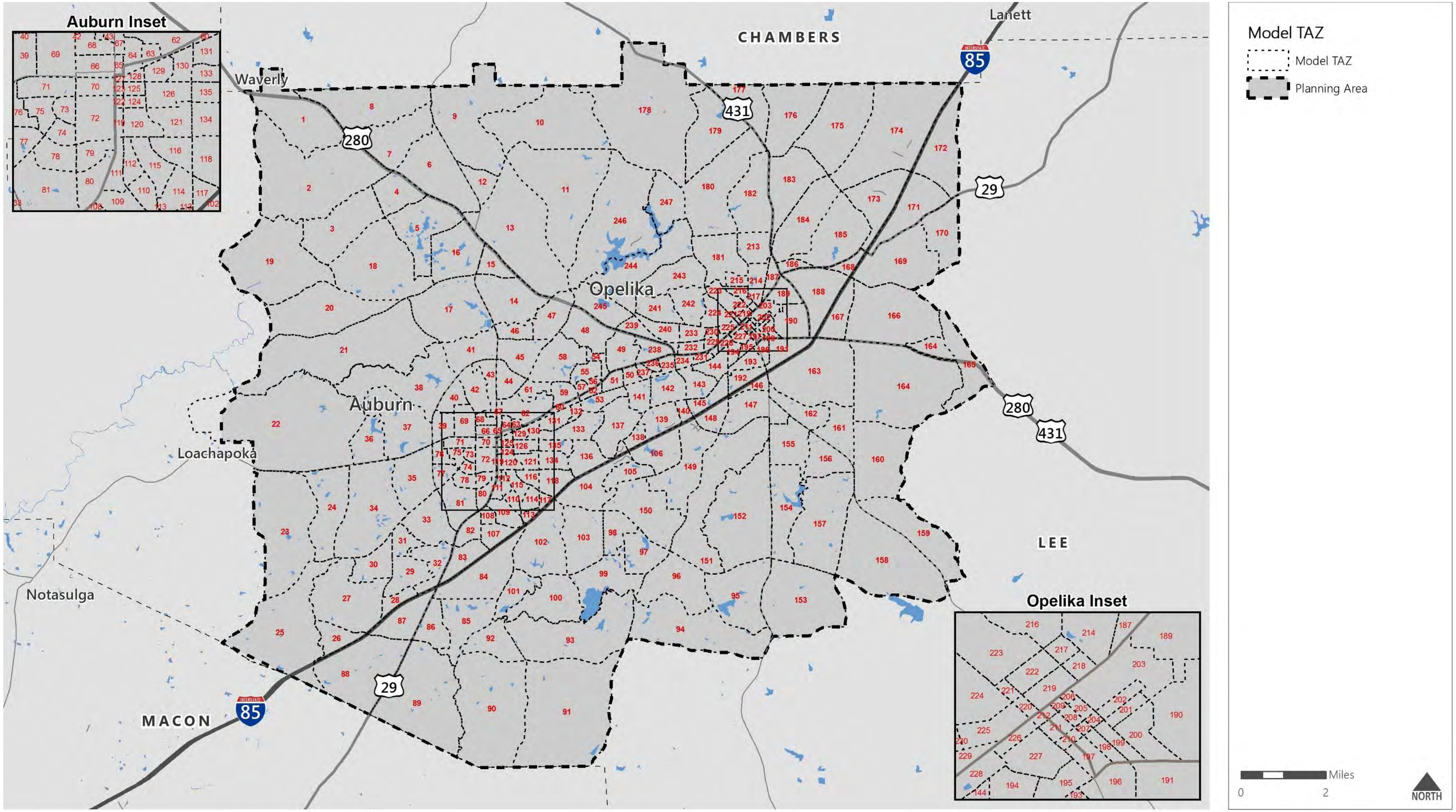
TAZs are generally homogeneous areas and were delineated based on:

- population
- land use
- census geography
- physical landmarks
- governmental jurisdictions

The LRTP 2045 study area and TAZ structure are an adjustment of the 2040 TAZ structure. These updated TAZs conform to the newest MPO study area boundary and subdivide older TAZs where necessary. The AOMPO LRTP 2045 study area was divided into 247 TAZs, all of which are within Lee County, Alabama. Additionally, there are 26 external stations. A map of the TAZs is shown in Figure 1.

The study area is comprised of the Cities of Auburn and Opelika, as shown in Figure 2.1.

Figure 2.1: AOMPO Study Area



Data Sources: Census Bureau; MPO Staff

Disclaimer: This map is for planning purposes only.

2.2 Base Year (2015) Model Socioeconomic Data Update

The previous TDM had a 2010 base year that used housing, employment, school enrollment, and income data as model inputs. The 2045 LRTP uses the same socioeconomic inputs but updated to 2015. This section describes the procedures used to update the socioeconomic model files to a 2015 base year.

Housing Data Update

2015 population and household data were developed by building from the 2010 Census. 2010 values were established for all TAZs using block-level Census data and then growth from 2010 to 2015 was calculated by identifying new households and group quarters in the MPA and applying an average household size to estimate population growth.

- New households and group quarters were identified in the following ways:
- A review of building permit data from 2010 to 2015 provided by Lee County and the City of Opelika;
- A review of news and media coverage of growth in the MPA from 2010 to 2015; and
- A time-lapse comparison of aerial and satellite imagery from Google Earth.

For the purposes of the model, household population was used in place of total population, which includes both households and group quarters. This was done because a special generator was developed for Auburn University, which accounts for the vast majority of group quarters population.

The population within the MPA in 2015 was 92,412 persons, living within 39,725 households.

Employment Data Update

The employment data used in the model was developed by Neel-Schaffer by reviewing and "cleaning" 2015 address-level employment data purchased from InfoGroup. This data allowed for Neel-Schaffer to classify each establishment in the MPA by type, number of employees, and TAZ location.

For Auburn University, employment was allocated to TAZs based on the location of campus parking.

The model uses employment based on two categories: retail and non-retail. Within the MPA there are 12,677 retail employees and 41,737 retail employees.

School Enrollment Data Update

K-12 and post-secondary schools in the MPA were identified using the National Center for Education Statistics and by reviewing online information from school districts. For K-12 schools, enrollment data was obtained from the National Center for Education Statistics for the 2015-2016 school year. For Auburn University, enrollment data by school was obtained from the university's Office of Institutional Research for the 2015-2016 school year. For other post-secondary schools, enrollment data was estimated by reviewing recent news articles and media.

For Auburn University, school enrollment was allocated to TAZs based on the location of campus parking.

School enrollment figures include public and private elementary, middle, and high schools; colleges; universities; vocational and business schools. Total school enrollment in the study area in 2015 was 46,793 students. For modeling purposes, the school enrollment is measured by the number of students attending a school in a traffic zone and *not* by the number of students residing in a traffic zone.

Income Data Update

Median household income data was developed for each TAZ based on recent block-group level data from the American Community Survey. When data was unavailable for a block group, median household income was estimated based on other economic data and income data for surrounding TAZs.

TAZ Data

The socioeconomic data for each TAZ are included in the TDM files. This data has been updated for the 2015 base year. The fields used in the TAZ layer are shown in Table 2.1.

Table 2.1: TAZ Field Attributes

Attribute Name	Description
ID	TAZ ID
Area	TAZ Area in Square Miles
TAZ	TAZ ID
POP15BA	Total Population
HH15BA	Occupied Dwelling Units/Households
RETAIL15BA	Retail Employment
NRETL15BA	Non-retail Employment
ENROLL15BA	School Enrollment
INCOME15BA	Median Household Income
ATYPE15BA	Area Type 1-3, Area Group 1, Urban 4-7, Area Group 2, Suburban 8, Area Group 3, Fringe 9, Area Group 4, Rural
Not that all "15BA" fields are repeated for "45EC", "35EC", "25EC", and "45PL" suffices.	

Source: NSI, 2019

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 Cube 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 the base year for accuracy, including:

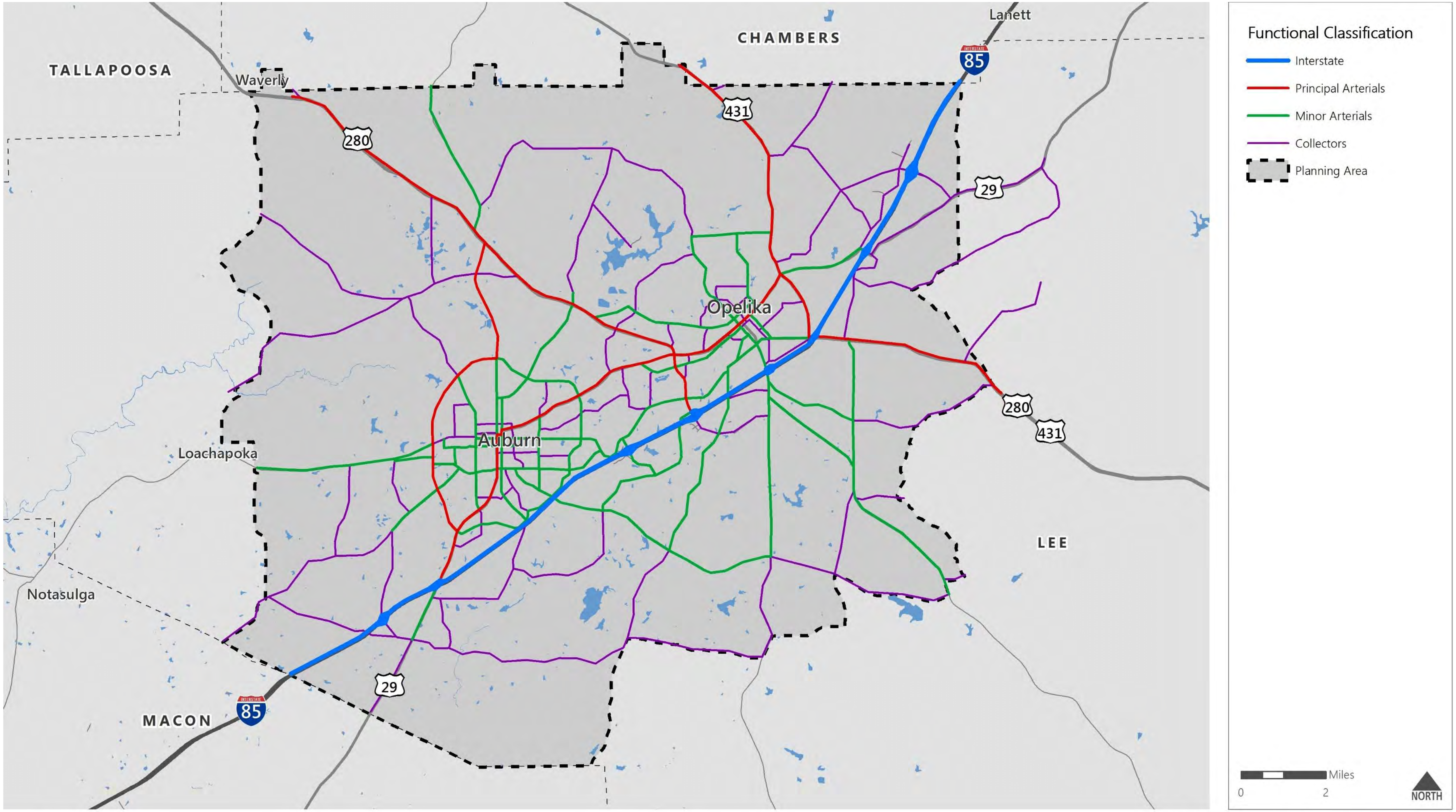
- number of lanes and/or turn lanes
- speeds
- functional classification to the most up-to-date data
- daily traffic counts and traffic stations (where necessary)

Each model scenario in the TDM contains its own roadway layer. These layers contain the records for all roadway links to be used for that scenario. Figure 3.1 displays the roadway network and link functional classifications used in the base year TDM run.

3.2 Functional Classification

Each link in the model's roadway network was assigned a functional classification based on the system maintained by the Alabama Department of Transportation (ALDOT). The functional classifications used in the TDM are shown in Table 3.1.

Figure 3.1: Roadway Network and Functional Classification



Data Sources: ALDOT

Disclaimer: This map is for planning purposes only.

Table 3.1: Functional Classification Used in AOMPO Model

Description	ALDOT Functional Classification Number
Interstate	1
Expressway	2
Principal Arterial	3
Minor Arterial	4
Major Collector	5
Minor Collector	6
Local	7
Ramp*	9*
Centroid Collector	99
* Ramps are not functionally classified by ALDOT but receive a classification for the purposes of the AOMPO TDM.	

Source: ALDOT

3.3 Model Link Speeds and Capacities

Roadway speeds have been updated in the new model to reflect the 2015 base year. This TDM effort uses the posted speeds instead of the prior TDM's lookup table which was based on area type and facility type. The model has also been updated with new capacity values that are based on ALDOT approved capacities that use the area type and facility type of the roadways. The network speeds can be found in the network file while the capacity lookup table can be found in the TDM files.

3.4 Centroid Connectors

Centroid connectors are imaginary roadway network links that connect a TAZ's 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. 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. This was accomplished by relocating the centroid for the TAZ to reflect the "center of mass" of developed land and/or moving the centroid connector roadway network access points to a location where trips generally enter or leave the TAZ. This 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 contains the most recent traffic counts available from ALDOT and reflect the 2015 base year. The update process included the verification of count stations upon the existing TDM links and ensuring that the ADTs are assigned to the correct link, with adjustments made as necessary.

3.7 Network Attributes

Table 3.2 displays the network attributes used on the links in the TDM.

Table 3.2: Model Link Attributes

Attribute Name	Description	Input Type
A	From Node	Automatic
B	To Node	Automatic
LENGTH	Link length (in miles)	Automatic
SPEED	Link speed (in miles per hour)	User*
CAPACITY	Link capacity	Model
FACTYPE	Model functional classification (Refer to Table 3.1)	User*
LANES	Total number of lanes	User*
AREATYPE	Link area type derived from TAZ	Model
STATION_NU	ALDOT AADT station number	User
AADT	Average Annual Daily Traffic on link	User
DIVIDED	Indicates roadway status 0= Roadway not divided 1= Roadway is divided	User*
ONEWAY	Indicates one-way status 0= Roadway is two-way 1= Roadway is one-way	User*
FUNCTCLASS	Model functional classification (Refer to Table 3.1)	User*
TAZ	TAZ the link is located within	User*

Attribute Name	Description	Input Type
TIME_FF	Free-flow travel time	Model
DISTANCE	Link distance from A to B	Model
GEOMETRY SO	Source of roadway geometry	Model
VC_1	24-hour volume/capacity	Model
CSPD_1	Link congested speed	Model
VOL_HBW	Daily home-based work volume	Model
VOL_HBO	Daily home-based other volume	Model
VOL_NHB	Daily non-home-based volume	Model
VOL_TKT	Daily truck volume	Model
VOL_IX	Daily internal-external volume	Model
VOL_XX	Daily external-external volume	Model
VOL_TOT	Total model volume	Model
VMT	Vehicle Miles Travelled	Model
VHT	Vehicle Hours Travelled	Model
*User must include these fields. Input types that are listed as Model are filled in using the TDM script.		

Source: NSI, 2019

4.0 External Travel

There are two types of external travel trips: external-internal (EI) trips and external-external (EE) trips. EI trips have one end of the trip inside the study area, and the other outside. EE trips pass through the study area and 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 study area's periphery. These stations represent most of the trips that are crossing the study area boundary.

The locations of the TDM's external stations are shown in Figure 4.1 and their traffic volumes are displayed in Table 4.1.

4.1 Trip Models

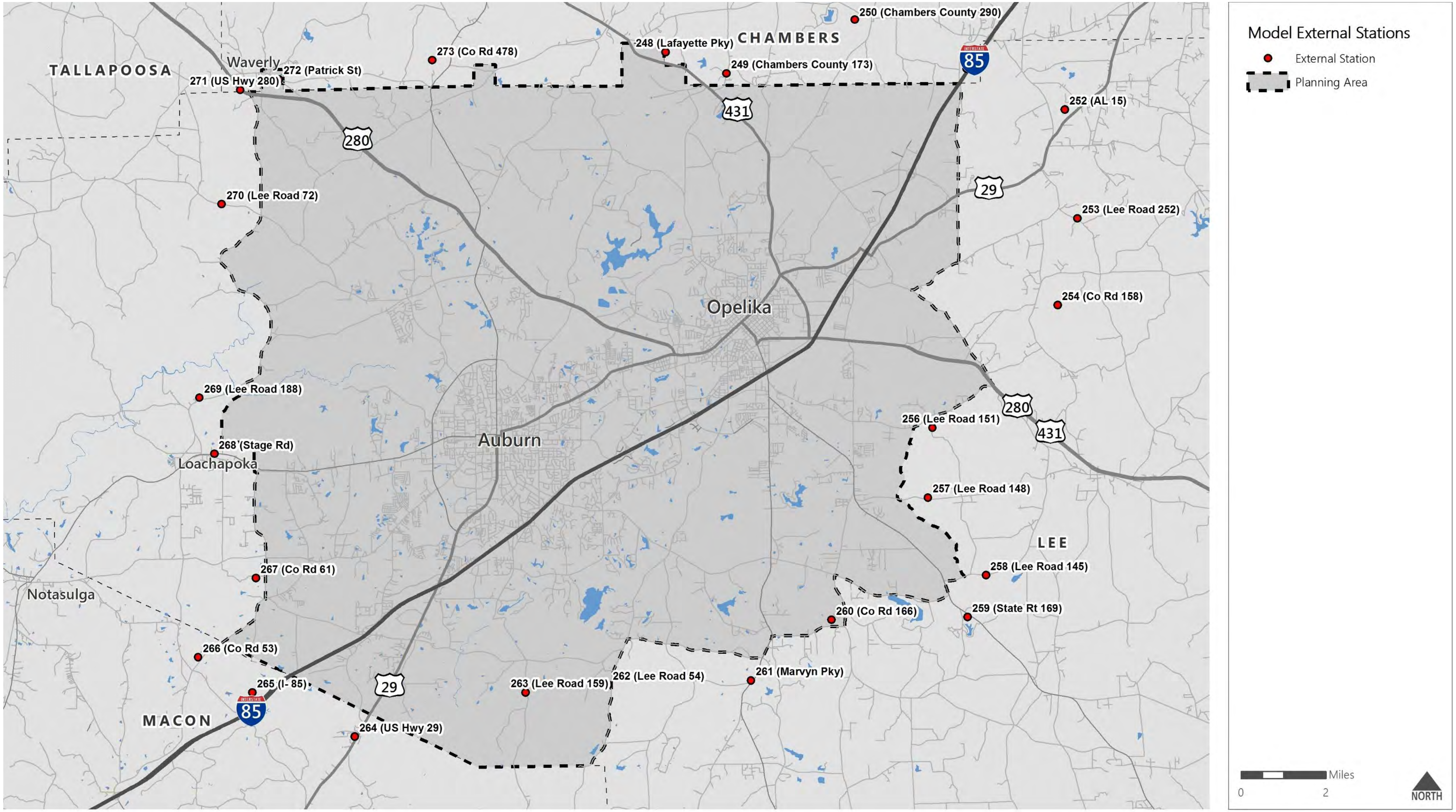
The LRTP 2045 TDM uses the same EE and EI trip models developed as part of the LRTP 2040 TDM. This results in 78,583 EE trips and 33,503 EI trips within the study area.

Table 4.1: External Station Traffic Volumes

Station Number	Description	Traffic Volume
248	US 431	2,770
249	Danway Road	210
250	County Road 389	330
251	I-85	34,490
252	AL 15	5,760
253	County Road 390	507
254	County Road 158	1,520
255	US 431	18,300
256	County Road 151	200
257	County Road 148	420
258	County Road 145	510
259	AL 169	4,110
260	County Road 166	2,980
261	AL 15	5,423
262	County Road 54	970
263	County Road 159	600
264	US 29	4,540
265	I-85	35,300
266	County Road 37	1,870
267	County Road 61	1,390
268	AL 14	5,700
269	County Road 81	700
270	County Road 72	2,040
271	US 280	11,640
272	Patrick Street	490
273	AL 147	2,590

Source: ALDOT, 2019

Figure 4.1: Model External Stations



Data Sources: ALDOT; MPO Staff

Disclaimer: This map is for planning purposes only.

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 amount 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)
- Truck (including Commercial Vehicles and Taxis)

Home-based trips are those that have one trip end located at the traveler's household. Examples of home-based trips include travel from home to work, shopping, or other personal business. Non-home-based trips include travel to and from any location that does not involve the traveler's household. Examples of these trips can include travel from work to shopping, from school to daycare, and from work to a lunch location.

Commercial vehicle trips are included in the truck trips for the purposes of the TDM and represent four-tire commercial vehicles. Commercial vehicles include delivery and service vehicles. Truck trips represent single-unit with six or more tires and multi-unit with three-plus axle combination trucks.

5.1 Internal Travel Model

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 TRK 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. This means that trip rates that vary by household type are applied at the zonal level. This TDM effort uses the same trip rates as the previous model, with the trip generation results checked for reasonableness in Section 5.3.

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, the TAZs that comprise Auburn University were identified as special generators. The MPA is largely a college town, which standard trip generation rates do not accommodate. As a result, the University generates more trips than the trip rates are expected to produce. Table 5.1 displays the additional productions and attractions added to the TDM to reflect the trips generated by Auburn University.

Table 5.1: Special Generator Productions and Attractions

TAZ	HBWP	HBOP	NBHP	HBWA	HBOA	NHBA
73	0	1,871	1,871	0	1,871	1,871
74	0	748	748	0	748	748
75	0	748	748	0	748	748
76	0	1,871	1,871	0	1,871	1,871
78	0	374	374	0	374	374
79	0	111	111	0	111	111
80	0	1,871	1,871	0	1,871	1,871
81	0	46	46	0	46	46

Source: NSI, 2019

5.3 Summary

Tables 5.2 and 5.3 display the validation measures used by the *Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee*, which was last updated in 2016, and the *Travel Model Validation and Reasonableness Checking Manual, 2nd Edition.*[2]

[2] Travel Model Validation and Reasonableness Checking Manual, 2nd Edition. Travel Model Improvement Program.

Table 5.2: Modeled vs Target Trip Rates

Validation Measure	Total Productions	Total Households	Total Population	Total Employees	Target Range	Actual Value
Person Trips Per Household	448,698	39,725			8.0 - 10.0	11.3
Person Trips Per Person	448,698		92,412		3.0 -5.0	4.9
HBW Trips Per Employee	58,563		.	54,414	< 2	1.1
Person Trips: All trips are displayed in person trips using the NCHRP 365 average auto occupancies. Values do not include Special Generators.						

Source: NSI, 2019

Table 5.3: Base Year Trip Generation Results; Trip Productions

Purpose	Trips	% Total Productions
HBW	58,563	11%
HBO	212,259	41%
NHB	99,523	19%
T-T	37,411	7%
I-E	78,353	15%
E-E	33,503	6%
Total	519,612	100%
Note: Values do not include special generators.		

Source: NSI, 2019

These statistics are within the reasonable limits established by the previously mentioned guidance except person trips which is elevated from the target range. However, this is not unexpected considering the MPA is host to a major university. No further adjustments were made since the model was performing well within all other benchmark ranges and persons were not directly used in the trip rates.

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 a direct one:

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 (impedance function) reflecting impedance between zone i and zone j

K_{ij} = Calibration parameter

n = Total number of zones in study area

6.2 Shortest Path 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 used in the calculation of F_{ij} as described in Section 6.1.

6.3 Friction Factors

Friction factors are another input used to calculate F_{ij}. This 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 an exponential function and friction factors developed using Streetlight Analytics data.

6.4 Terminal Times

Terminal times reflect additional travel that is associated with a trip. These 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, based on the area type of a TAZ. Those TAZs that are Area Type 1, 2, or 3 receive a three (3) minute terminal time. All other Area Types receive a one (1) minute terminal time.

6.5 Trip Length Frequency Distribution

The average trip lengths obtained from the model are displayed in Table 6.2. These trips lengths are also compared to the target trip times and the Streetlight data used to develop the friction factors.

Table 6.2: Average Trip Length by Trip Purpose

Trip Purpose	Target Trip Time (minutes)	Streetlight Trip Time (minutes)	Modeled Trip Time (minutes)
HBW	13 to 15	13.60	12.80
HBO	11 to 12	13.20	12.40
NHB	9 to 10	12.30	10.80
T-T*	-	-	-
I-E*	-	15.90	15.70
E-E*	-	-	-
*Target range not established			

Source: Streetlight, 2019; NCHRP 365/716; NSI, 2019

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 LRTP 2045 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 area type and functional classification. The assignment process used in the TDM analyzes link and intersection delay. 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 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= BPR coefficients

This 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 are the same as the previous effort.

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, 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. This is because 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 ensure that the model is performing within the limits that define acceptable ranges of deviation from observed "real-world" values.

As stated previously, this modeling effort uses the *Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee* and the *Travel Model Validation and Reasonableness Checking Manual, 2nd Edition*, as guidelines for the validation of TDMs.

The following criteria were used to validate the AOMPO TDM:

- Percent Deviation by AADT Group
- Percent Deviation by Roadway Functional Classification
- VMT and VHT Measures
- Percent Root Mean Square Error
- Coefficient of Determination

8.1 Percent Error

The first measure of model validation is the percent error, or percent deviation, of the model's assigned traffic volumes to the observed traffic counts. Tables 8.1 and 8.2 display the validation results by AADT group and functional classification, respectively.

Table 8.1: Percent Deviation by AADT Group

ADT Range	Number of Observations	Total Count	Total Model Volume	% Dev	% Dev Limit
ADT<1,000	55	32,368	51,220	58.2	200.0
1,000 < =ADT < 2,500	69	129,080	127,085	-1.5	100.0
2,500 <= ADT < 5,000	107	383,450	380,317	-0.8	50.0
5,000 <= ADT < 10,000	115	847,194	864,186	2.0	25.0
10,000 < =ADT <25,000	133	2,123,935	1,999,829	-5.8	20.0
25,000 < =ADT < 50,000	16	463,335	424,382	-8.4	15.0
Areawide	496	3,984,362	3,853,007	-3.3	5.0

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee; NSI, 2019

Table 8.2: Percent Deviation by Functional Classification

Functional Classification	Links with Counts	Total Count	Total Model Volume	% Difference	FHWA Target	Average Congested Speed
Interstate	18	372,220	409,112	9.9%	+/- 7%	56
Principal Arterial	75	1,331,120	1,206,883	-9.3%	+/- 10%	45
Minor Arterial	207	1,630,120	1,599,816	-1.9%	+/- 15%	39
Collector	170	505,540	491,834	-2.7%	+/- 15%	41
Areawide	496	3,984,362	3,853,007	-3.3%	+/- 5%	-

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee; NSI, 2019

The model estimated freeway volumes deviated by +9.9% from the reported ALDOT counts whereas the allowable deviation is +/- 7%. However, when looking at the ramp and corresponding upstream and downstream freeway counts, it seems some of the counts listed are lower than expected. Due to this, no further adjustments were made to lower the model estimated freeway volumes.

8.2 VMT and VHT Measures

The VMT and VHT are two values calculated by the model that can be used to indicate the level of congestion experienced within the model. Table 8.3 displays the calculated validation measures of these two indicators.

Table 8.3: VMT and VHT Validation Measures

Trip Assignment	VMT	Average	VHT	Total Households	Total Population
VMT & VHT - Total	3,048,144	80,135			3,048,144
VMT & VHT - Per Household	76.7	2.0	39,725		76.7
VMT & VHT - Per Person	33.0	0.9		92,412	33.0

Source: NSI, 2019

The area experiences slightly above-average VMT per household and VMT per person; however, this is likely due to the presence of Auburn University and the trips it generates.

8.3 Percent RMSE

The RMSE measure was chosen because when comparing model flows versus counts, sometimes a direct 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:

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

The RMSE validation results are shown in Table 8.4

Table 8.4: RMSE Validation Measures

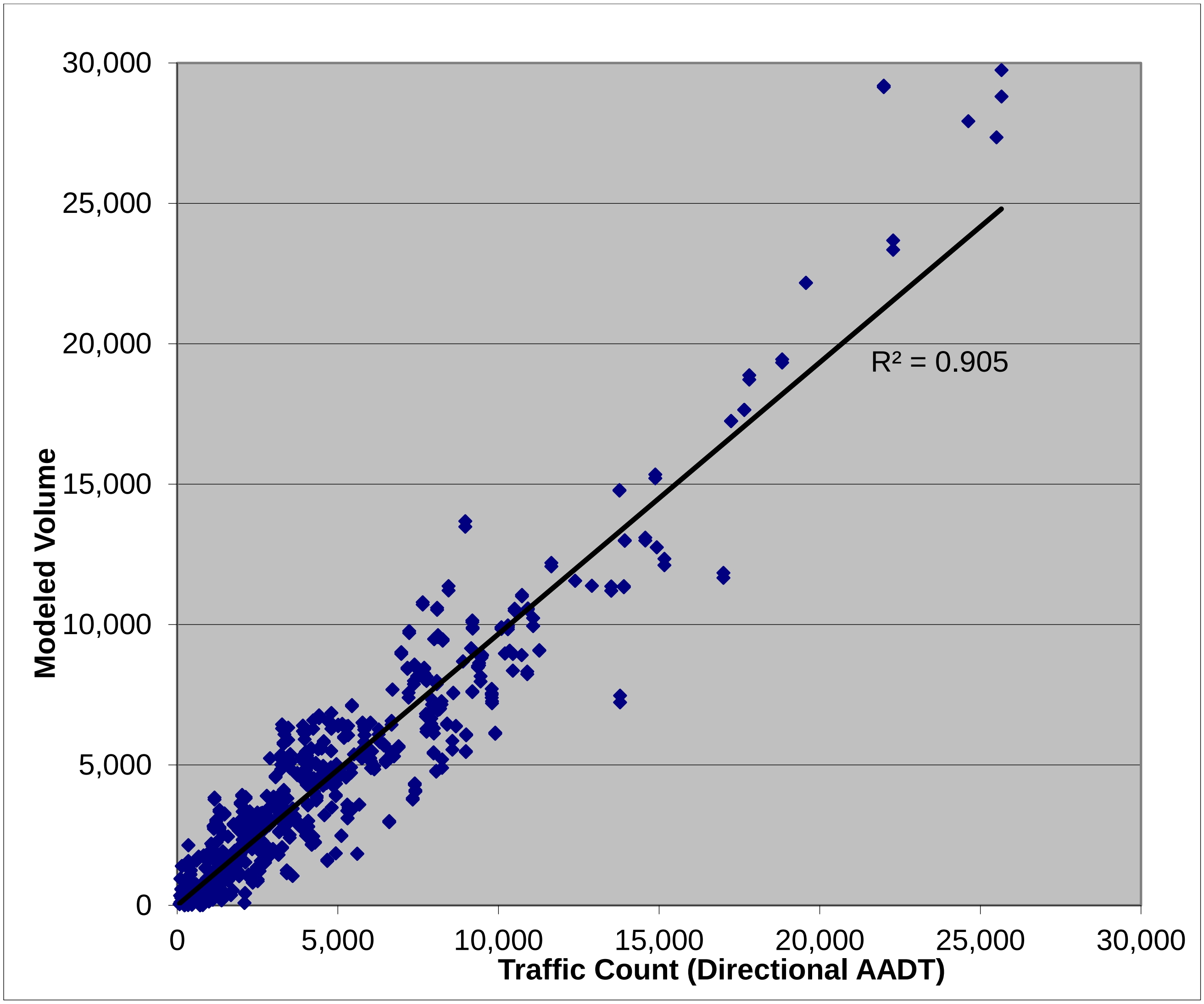
ADT Range	Number of Observations	Total Count	Total Model Volume	% RMSE	% RMSE Limit
ADT<5,000	231	544,898	558,622	62.1	45.0 - 100.0
5,000 <= ADT < 10,000	116	852,194	870,173	34.5	35.0 - 45.0
10,000 < =ADT < 15,000	54	657,620	602,364	25.7	27.0 - 35.0
15,000 < =ADT < 20,000	57	986,430	933,043	20.5	25.0 – 30.0
20,000 < =ADT < 30,000	34	809,100	770,290	16.4	15.0 – 27.0
30,000 < =ADT <50,000	4	134,120	118,515	17.1	15.0 – 25.0
Areawide	496	3,984,362	3,853,007	31.3	35.0 – 45.0
Functional Classification	Number of Observations	Total Count	Total Model Volume	% RMSE	% RMSE Limit
Interstate	18	372,220	409,112	14.1	20.0
Principal Arterial	75	1,331,120	1,206,883	20.4	30.0
Minor Arterial	207	1,630,120	1,599,816	34.7	40.0
Collector	170	505,540	491,834	55.2	70.0

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee; NSI, 2019

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. This value ranges between zero (0) and one (1). The closer the value is to one (1), the better the correlation between counts and model volumes. The established guidance from FHWA and the *Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee* recommend a minimum R^2 of 0.88. The areawide coefficient of this TDM effort was 0.91 and a scatter plot of the results is shown in Figure 8.1.

Figure 8.1: Modeled Volume vs Traffic Count Plot



8.5 Screenlines

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. This TDM effort uses several screenlines. The results of the screenline analysis are shown in Table 8.5 while Table 8.6 displays the comparison of the assigned volumes to traffic counts on select major roadways within the MPA.

Table 8.5: Screenline Analysis

Number	Screenline	2015 Assign Volume	2015 Traffic Count	Volume / Count Ratio	Percent Deviation from Base	Maximum Desirable Deviation
1	North & South Split of Auburn and Opelika City Limits	45,293	50,280	0.90	-10%	(+/-) 18%
2	In & Out of Opelika	64,909	64,120	1.01	1%	(+/-) 17%
3	In & Out of Auburn	122,081	125,240	0.97	-3%	(+/-) 13%
4	North of I-85	62,121	68,470	0.91	-9%	(+/-) 17%
5	South of I-85	69,931	69,470	1.01	1%	(+/-) 16%
*	I-85	368,500	327,330	1.13	13%	(+/-) 9%
*	Major Roadways	177,029	188,200	0.94	-6%	(+/-) 11%
	Total	909,864	893,110	1.02	2%	(+/-) 6%

***Note:** These are compilations of either Interstate, Principal Arterial, or Collector links on major roads in the MPA and are not considered screenlines.

Table 8.6: Model Assigned Volumes with Traffic Counts at Selected Major Roadways

Major Roadways	2015 Assign Volume	2015 Traffic Count	Volume / Count Ratio	Percent Deviation from Base	Maximum Desirable Deviation
Birmingham Highway North of Patrick Street	11,640	11,640	1.00	0%	(+/-) 32%
Birmingham Highway East of Waverly Parkway	13,040	15,490	0.84	-16%	(+/-) 29%
Pepperell Parkway West of Veterans Parkway	30,501	29,770	1.02	2%	(+/-) 22%
Martin Luther King Drive East of Shug Jordan Parkway	12,013	10,380	1.16	16%	(+/-) 34%
South College Street South of Longleaf Drive	26,060	29,150	0.89	-11%	(+/-) 23%
Gateway Drive South of Fredrick Road	24,801	30,330	0.82	-18%	(+/-) 22%
Marvyn Parkway South of Gateway Drive	9,216	9,130	1.01	1%	(+/-) 35%
Columbus Parkway West of Uniroyal Road	22,761	25,820	0.88	-12%	(+/-) 24%
Lafayette Parkway North of Cusseta Road	3,152	3,200	0.99	-2%	(+/-) 53%
Pepperell Parkway East of Veterans Parkway	23,845	23,290	1.02	2%	(+/-) 25%

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

A future year model was developed to forecast traffic that the study area will experience based on its anticipated growth. This includes forecast 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 allocated funding in the near future.

9.1 Future Year Socioeconomic Projections

To adequately forecast future transportation system needs, projections of demographic variables in the year 2045 were developed for each Traffic Analysis Zone (TAZ).

Population and Employment Growth

Study area population and employment control totals for the year 2045 were derived using county level forecasts for Lee County provided by the by Center for Business and Economic Research (CBER) at the University of Alabama. Specifically, study area control totals were developed by estimating the study area's future share of county population and employment.

- For population, the study area's share of county population is projected to increase from 63.0% in 2010 to 72.9% in 2045, based on recent trends and concentration of development in and near the urbanized area.
- For employment, the study area's share of county employment is projected to increase from 90.0% in 2015 to 93.7% in 2045, based on recent trends and concentration of development in and near the urbanized area.

After control totals were developed for the study area, growth was then sub-allocated to each Traffic Analysis Zone in the travel demand model.

- First, growth that occurred after the base year was added, based upon a review of recent news articles, planning commission reports, and satellite imagery.
- Then, a GIS-based growth model was used to allocate the remaining growth through 2045. This growth model evaluated the attractiveness of each Traffic Analysis Zone for residential, commercial, and industrial development and estimated its capacity for such development based on existing land development patterns and future land use regulations.

Figures 9.1 and 9.2 show the projected growth in population and employment by TAZ.

<u>School Enrollment Growth</u>

For public primary and secondary schools, enrollment growth was projected for each school based upon the projected population growth rates in its “attendance zone.” Growth rates for each “attendance zone” were developed by assigning each TAZ to a school, based on proximity and school zone boundaries, and then calculating the population growth rate for these areas from 2015 to 2045. New schools and relocations were also included:

- Auburn High School – this school relocated to a new facility in Fall 2017. Auburn Junior High School moved into its former location and East Samford School moved into the former junior high school.
- Creekside Elementary School – this school opened in Fall 2018.
- Planned “Northwest” high school in Auburn – to be located near Richland Road and Highway 14.
- Planned new “Yarborough” elementary school in Auburn – to be located near the existing Yarborough Elementary school.

For private primary and secondary schools and all colleges/universities except for Auburn University, student enrollment was assumed to grow in proportion to overall population growth.

For Auburn University, growth will be less rapid due to plans to limit undergraduate enrollment to 25,000 students, similar to current levels. For planning purposes, growth at Auburn University is projected to increase from approximately 27,000 students (undergraduate, graduate, and others) in 2015 to approximately 34,000 students in 2045.

Table 9.1: Population and Households by Year

Variable	2015	2045
Total Population	96,811	160,468
Household Population	92,412	154,669
Households	39,725	66,988

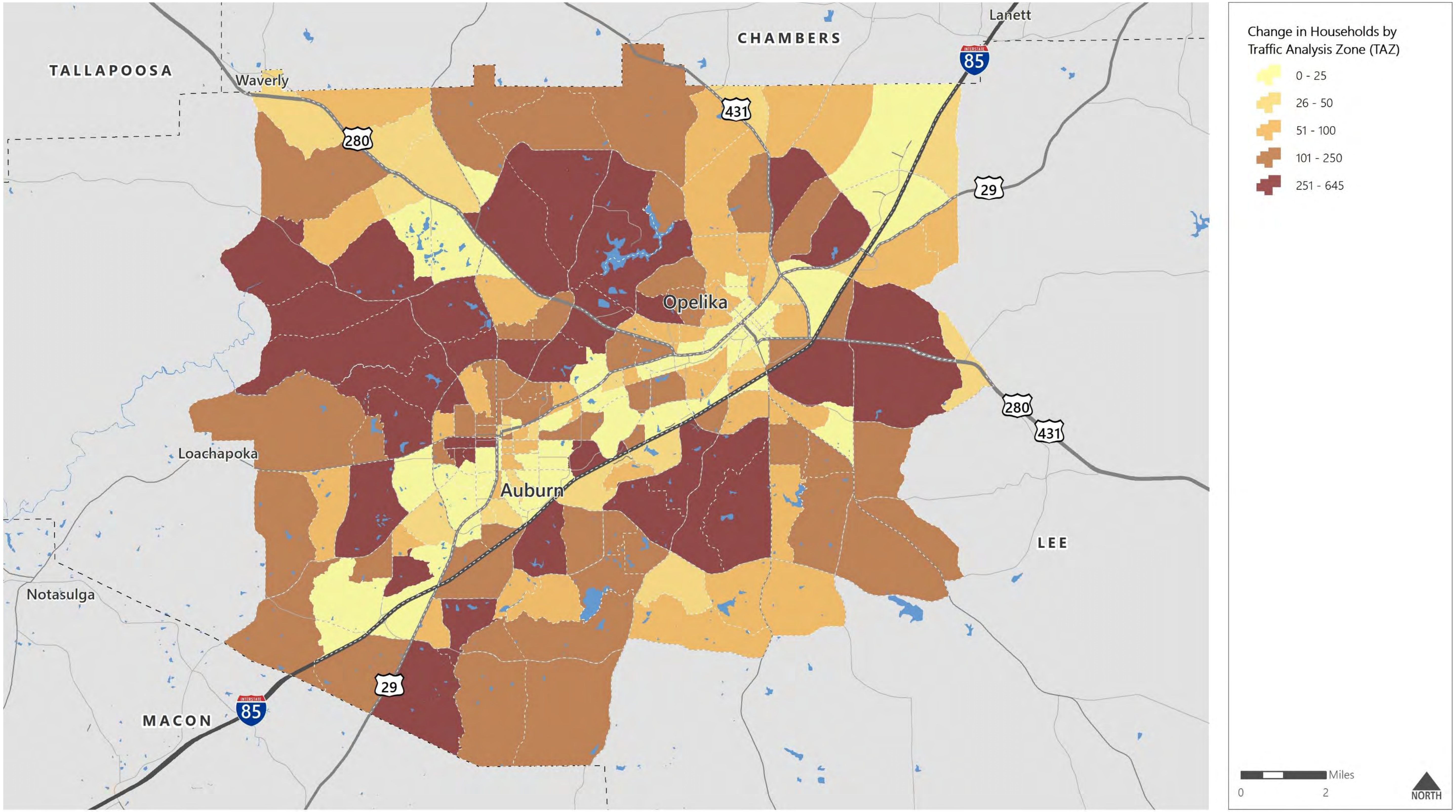
Source: NSI, 2019

Table 9.2: Employment by Year

Variable	2015	2045
Total Employment	54,414	74,830
Retail Employment	12,677	18,769

Source: NSI, 2019

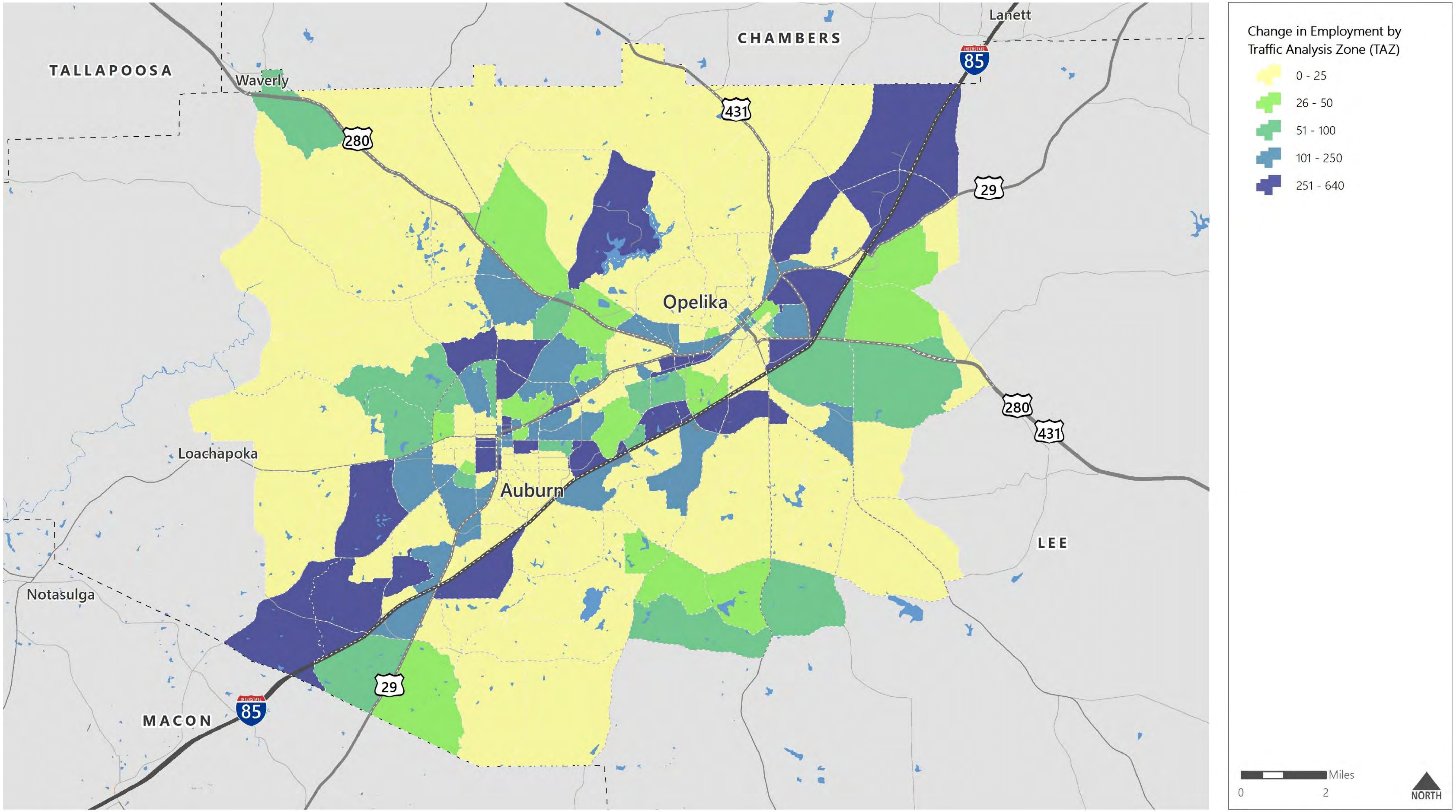
Figure 9.1: Household Growth, 2015-2045



Data Sources: Neel-Schaffer, Inc.

Disclaimer: This map is for planning purposes only.

Figure 9.2: Employment Growth, 2015-2045



Data Sources: Neel-Schaffer, Inc.

Disclaimer: This map is for planning purposes only.

9.2 Existing Plus Committed (E+C) Network

The base year network was defined as the street and highway system that existed in year 2015. Once the base year network was calibrated, the E+C network was developed which included committed projects.

Committed projects are those improvements for which:

- construction was either completed or begun since 2015,
- a contract for construction has been awarded,
- have completed the National Environmental Policy Act (NEPA) phase, or
- have funding for right-of-way and/or construction programmed in the MPO’s Transportation Improvement Program.

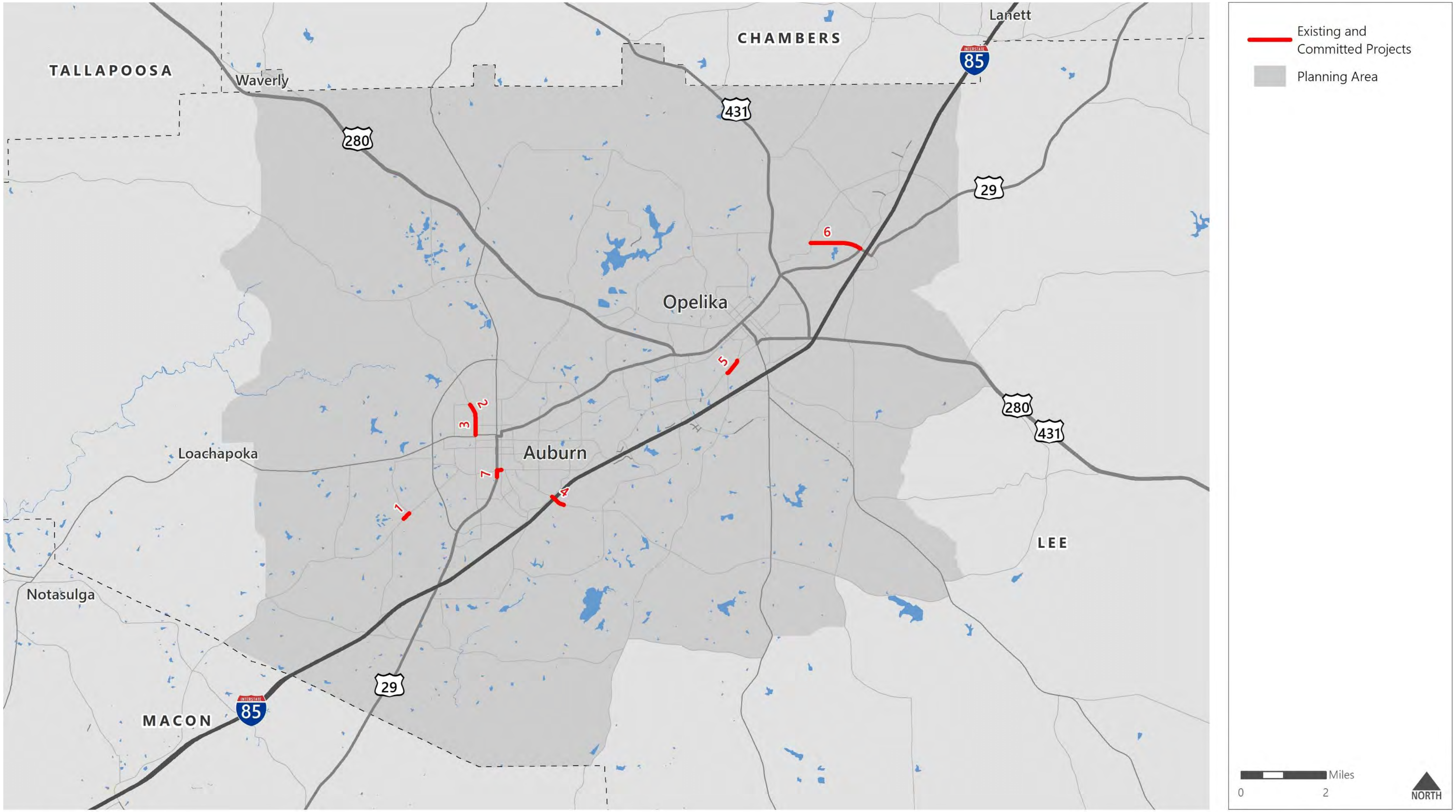
The committed projects are listed in Table 9.3 and shown in Figure 9.3.

Table 9.3: Existing Plus Committed Projects

Map ID	Status	Roadway	Location	Improvement
1	Existing	Wire Rd	Webster Rd to Eagle Landing RV Park	Center Turn Lane
2	Existing	N Donahue Dr	Cary Dr to Bedell Ave	Center Turn Lane
3	Committed	N Donahue Dr	Bragg Ave to Cary Dr	Center Turn Lane
4	Existing	Moore's Mill Rd	E University Dr to Grove Hill Rd	Widen From 2 to 4 Lanes with center turn lane
5	Existing	Frederick Rd Extension	S Long St to Auburn St	New 2 Lane Roadway
6	Existing	Sportsplex Pkwy	I-85E Exit 64 to Andrews Rd	New 2 Lane Roadway
7	Committed	S College (SR-147)	South College St: Garden Dr to Samford Ave; Samford Ave and Gay St	New lane; Drainage; Add Turn Lane

Source: AOMPO, ALDOT

Figure 9.3: Existing Plus Committed Projects



Data Sources: Neel-Schaffer, Inc.

Disclaimer: This map is for planning purposes only.

9.3 External Station Growth

Forecast traffic volumes to 2045 for the TDM's external stations were provided by ALDOT where count station data was available. Where external stations do not have a count station, estimates of reasonable growth rates were applied to the 2015 volumes based on regional trends. The final forecast growth rates for each external station and a comparison of external travel forecast for the base year and horizon year is shown in Table 9.4.

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 (2015) or the horizon year (2045).

Table 9.4: External Station Forecast Growth

External Station	Forecast Annual Growth Rate	2015 Volume	2045 Volume
248	1.3%	2,770	4,080
249	1.0%	210	283
250	1.0%	330	445
251	1.4%	34,490	52,184
252	1.6%	5,760	9,164
253	1.0%	507	683
254	1.0%	1,520	2,049
255	1.3%	18,300	26,961
256	1.0%	200	270
257	1.0%	420	565
258	1.0%	510	687
259	1.5%	4,110	6,368
260	1.0%	2,980	4,016
261	1.0%	5,423	7,309
262	1.0%	970	1,308
263	1.0%	600	809
264	1.6%	4,540	7,223
265	1.4%	35,300	53,411
266	1.0%	1,870	2,521
267	1.0%	1,390	1,873
268	1.5%	5,700	8,909
269	1.0%	700	943
270	1.0%	2,040	2,749
271	1.4%	11,640	17,560
272	1.0%	490	661
273	1.7%	2,590	4,358

Source: AOMPO; NSI, 2019