

BALDWIN COUNTY TRAVEL DEMAND MODEL



PREPARED FOR



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S A I N
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This document serves as the model documentation for the Baldwin County Year 2050 Travel Demand Model. The accompanying TransCAD and Shapefiles have been provided to County staff and ALDOT.

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Table of Contents

Introduction.....	1
Key Concepts of the Travel Demand Model.....	1
Trip Generation	1
Trip Distribution	1
Mode Choice.....	1
Assignment	1
Model Calibration	2
Parameters	12
Highway Network.....	12
Local Streets	12
Speeds and Capacities	15
Planning Areas	18
Traffic Analysis Zones	21
Socio-economic Data	21
Base Year Data	21
Trip Generation	25
Capacity Restraint	26
Model Validation	27
Screenlines.....	27
Foley Beach Express Toll.....	31
K-Factor Effects on the Bayway.....	32
Seasonal Trip Origins and Destinations	32
External Volumes	33
Future Year Data	35
Population	35
Growth Rates for 2050 Socio-Economic Projections	35
Comprehensive Plans	36
Households	36
Employment	36
Quality Control	44
No-Build Network	48
Conclusions	48

List of Figures

Figure 1 Friction Factor Curves	3
Figure 2 Home Based Work Trip Length Distribution.....	6
Figure 3 Home Based Other Trip Length Distribution	7
Figure 4 Non Home Based Trip Length Distribution	8
Figure 5 Truck and Taxi Trip Length Distribution.....	9
Figure 6 Internal External Trip Length Distribution	10
Figure 7 External External Trip Length Distribution	11
Figure 8 ALDOT 2021 Functional Classification Map	13
Figure 9 Base year Functional Classification	14
Figure 10 Example of Baldwin County Centroid Connectors	15
Figure 11 Base Year Planning Areas	19
Figure 12 Future year Planning Areas	19
Figure 13 Network Coding of Planning Area	20

Figure 14 Existing Households by TAZ.....	22
Figure 15 Existing Retail Employment by TAZ	23
Figure 16 Existing Non-Retail Employment by TAZ	24
Figure 17 BPR Capacity Restraint Curve	26
Figure 18 Screenline Error for Baldwin County and the ESMPO	28
Figure 19 Screelines of Baldwin Couty.....	29
Figure 20 RMS Error by Functional Classification	30
Figure 21 RMS by Volume Group	32
Figure 22 K-Factor on SR-225	34
Figure 23 Various Population Forecasting Methodologies.....	37
Figure 24 Various Population Forecasting Methodologies.....	38
Figure 25 Various Population Forecasting Methodologies.....	39
Figure 26 Land Cover and Flood Zones	40
Figure 27 Guide to Growth	41
Figure 28 Commercial and Residential Structures	42
Figure 29 Buffer from Principal Arterials	43
Figure 30 Baldwin County Future Employment	44
Figure 31 Future Households by TAZ	45
Figure 32 Future Retail Employment by TAZ	46
Figure 33 Future Nonretail Employment by TAZ.....	47
Figure 34 Future Existing and Committed Network.....	49

List of Tables

Table 1 Friction Factors	3
Table 2 Facility Codes.....	13
Table 3 Speeds of ESMPO Network	13
Table 4 Capacities of the ESMPO Network.....	13
Table 5 Planning Area Classification	15
Table 6 Base and Future Year Socio-Economic Data	22
Table 7 Trips per Household Income by Veh/HH.....	22
Table 8 Percent of vehicles per HH by Income level.....	23
Table 9 External Stations	29

Appendix A: Abbreviations

Introduction

The Baldwin County travel demand model (TDM) was created within the software TransCAD with the support of Alabama Department of Transportation (ALDOT). As of December 2025, ALDOT will no longer be supporting the travel demand software CUBE. All MPOs in the State of Alabama are migrating to TransCAD. ALDOT provides funding for the software and maintenance fees to Caliper in order for the MPOs to be licensed for TransCAD. The ESMPO CUBE TDM was translated by Caliper to TransCAD. However, Sain Associates expanded the parameters of that model, and under a separate contract with Baldwin County Highway Department expanded the geographic area to include all of Baldwin County.

Key Concepts of the Travel Demand Model

The Baldwin County Travel Demand Model is a traditional four-step model (Trip Generation, Trip Distribution, Mode Choice; Assignment). The model does not include the mode choice step. Mode choice is specifically for travel demand models that have a transit system with a large presence of trips using a fixed route transit. There is no fixed route transit in Baldwin County.

Trip Generation-Demographic data is used to generate productions at the household level and attractions based on employment. NCHRP 716 was utilized for the trip generation methodology, although slightly catered to Baldwin County due to post COVID trip patterns. This step creates Productions and attractions for numerous trip purposes, Home Base Work (HBW), Home Base Other (HBO), Non-Home Based (NHB), Truck and Taxi (TKT), Internal / External (I/E), and External / External (E/E). There is not a separate freight model depicting trucks.

Trip Distribution- A traditional gravity-based trip distribution model is used to distribute the productions and attractions by trip purpose (from the trip generation step) to create origins and destinations. The origin is the TAZ where each trip begins, and the destination is the TAZ where each trip ends. The standard gravity model was used for Trip Distribution. The gravity model uses the productions and attractions from the Trip Generation step, the travel time matrix between each TAZ, and friction factors to generate a single vehicle TAZ to TAZ trip matrix. The trip matrix summarizes the vehicle trips between each TAZ in Baldwin County. There are 592 internal TAZs in Baldwin County with 12 external zones.

Mode Choice-A logit model is used to estimate whether people choose fixed route transit versus driving in a car alone or carpooling. (Note: this step is missing from the Baldwin County model chain as BRATS is demand response)

Assignment- The trips resulting from the Trip Distribution step (and mode split) are loaded onto the network during Trip Assignment. Trips originating from a TAZ are applied to the network through the centroid connectors. Those trips travel to the destination TAZ through the network and ultimately to the destination TAZ via the centroid connector.

The trips are applied to the network until the network reaches equilibrium. An equilibrium assignment uses an iterative process to optimize the overall travel time for all trips in the model. By

combining information from various iterations, the number of iterations required to reach equilibrium is reduced. The network is considered to be in equilibrium when no traveler can improve his or her travel time using an alternative path. (Note: the trip tables from the Trip Distribution step are used in Assignment as there is no mode choice model in the Baldwin County model chain).

Model Calibration

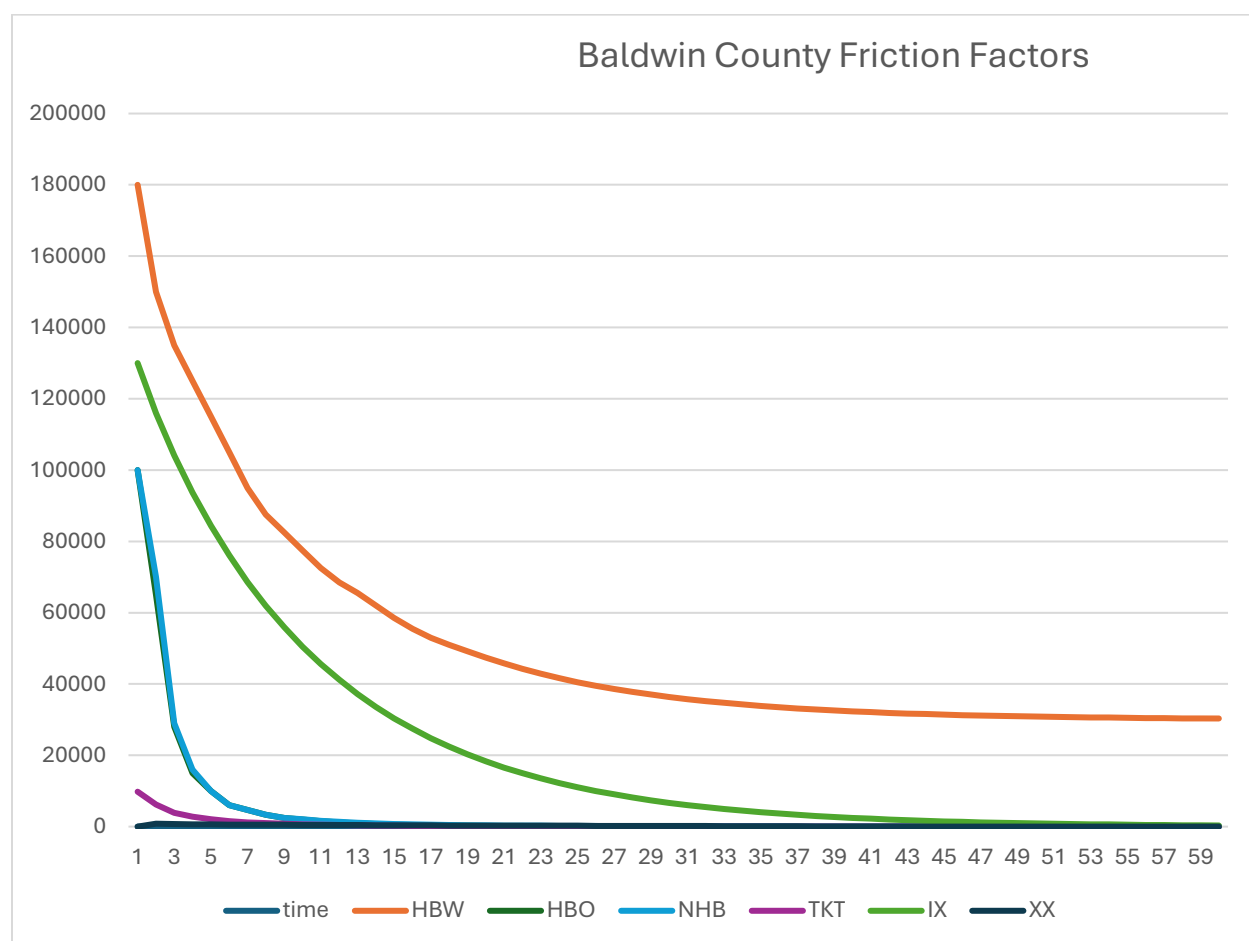
The model assumes that the trips produced in a traffic analysis zone are attracted to other traffic analysis zones in direct proportion to the attractions in the other traffic analysis zones, and inversely proportional to the distance between the traffic analysis zones. In order to assume a model is as accurate as possible, the gravity model must be calibrated. Model calibration is the process of adjusting parameter values until the predicted travel matches the observed travel within the study area. In the Baldwin County model, these are guided through a function known as friction factors.

The calibrating term "friction factor" represents the reluctance or impedance of people to make trips of various duration or distances. The general friction factor indicates that as travel times increase, travelers are increasingly less likely to make trips of such lengths. Calibration of the gravity model involves adjusting the friction factors to several types of trip purposes. Examples of these trip purposes are Home Based Work (HBW), Home Based Other (HBO), Non-Home Based (NHB), Truck and Taxi trips (TKT), Internal -External Trips (IE) and External-External (EE) trips. The friction factors guide the gravity model by purpose. The model is calibrated when the trip length frequency, trip length distribution and other parameters match both the real-world observances to those produced by the model.

It has been historically difficult to obtain data to ensure the predicted travel matches the observed travel with comparative trip patterns. In 2019, the company Citilabs that owned and maintained the travel demand software that the Metropolitan Planning Organizations (MPOs) in Alabama used at the time (CUBE Voyager), was contracted by ALDOT to develop friction factors for every MPO in the State. Through a program called Streetlytics, Citilabs used cell phone data available to compare observed data to predicted data and presented each MPO with its own friction factors. The friction factors that guided the Baldwin County gravity model (Figure 1) are specific to Baldwin County and are used to ensure the model's accuracy. The friction factors below are specific to Baldwin County and are comparable to guidance such as the NCHRP 716.

TransCAD distributes trips by purpose (HBW, HBO, NHB, and TKT) using a gravity model. This process pairs trip productions with attractions by weighing the distance or travel time against specific friction factors for each trip type. The percentages of productions by trip purpose were carried over from the ESMPO Cube Model that was migrated by Caliper, and were not changed at HBW (.18), HBO (.50), NHB (.32) and TKT (.05). Although this equates to 1.05, the attractions are balanced to the productions.

Figure 1 Friction Factor Curves



The Friction Factors (Table 1) control the trip length, trip frequency and trip distribution of the travel demand model. They were provided by ALDOT and developed by Street Analytics (Citilabs) based on real data from cell phone usage. The friction factors were migrated from the ESMPO Cube model to the Baldwin County TDM. It is assumed that the ESMPO Cube gravity model was calibrated with the current friction factors and are sufficient friction factors for the Baldwin County TransCAD model. Figures 2-7 are the trip length distributions and trip lengths for the separate trip purposes for the Baldwin TDM.

Table 1 Friction Factors

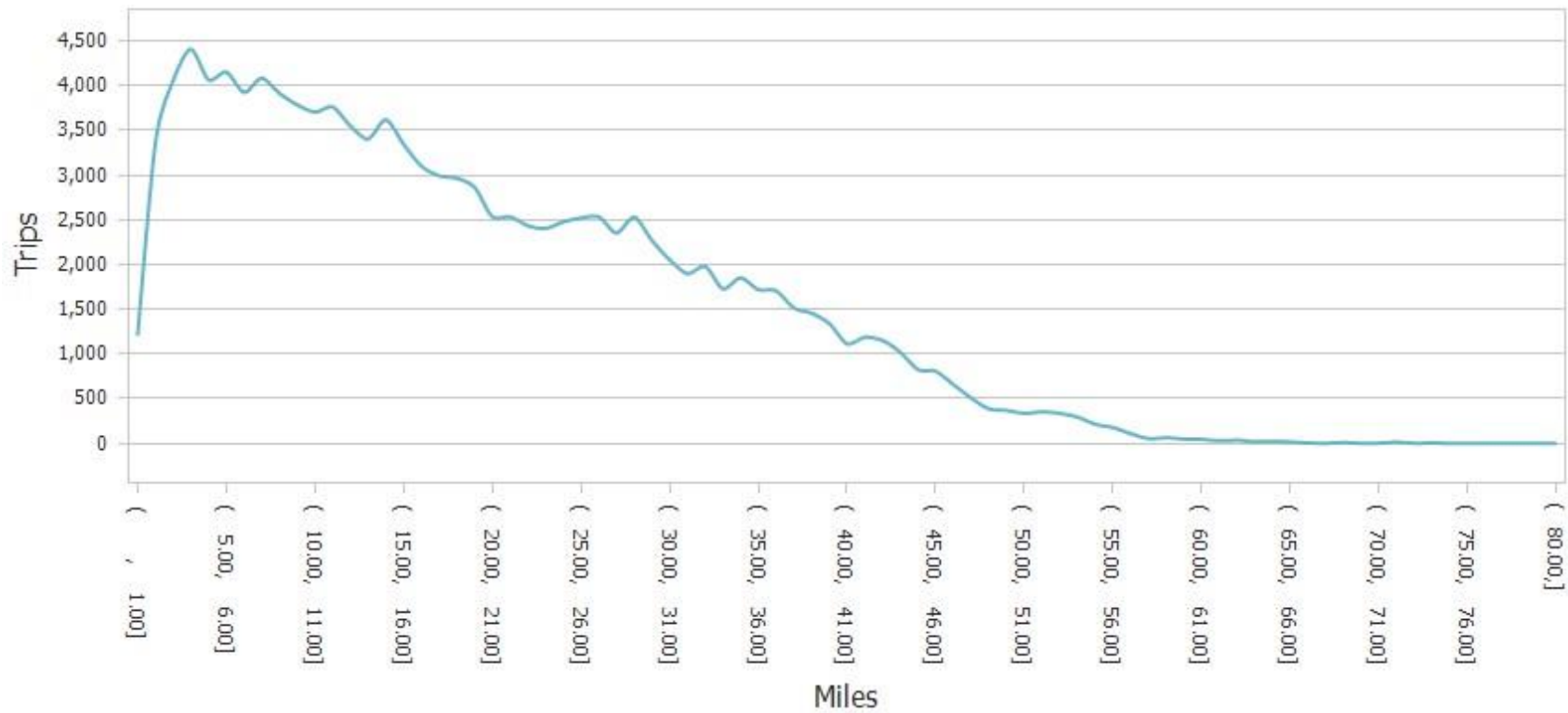
<u>TIME</u>	<u>HBW</u>	<u>HBO</u>	<u>NHB</u>	<u>TKT</u>	<u>IX</u>	<u>XX</u>
1	180000	100000	100000	9800	130000	0
2	150000	65000	70000	6200	116009	825
3	135000	28000	29000	3900	104122	700
4	125000	15000	16000	2770	93673	660
5	115000	9999	9999	2030	84381	625

6	105000	6000	6000	1570	76073	580
7	95000	4700	4700	1200	68622	560
8	87500	3300	3300	970	61926	535
9	82500	2400	2400	790	55901	508
10	77500	1947	2093	640	50475	480
11	72500	1498	1662	530	45585	460
12	68500	1169	1342	425	41175	440
13	65500	923	1098	350	37197	418
14	62000	737	910	290	33608	395
15	58500	593	762	250	30367	359
16	55500	481	643	210	27442	340
17	53000	392	547	170	24801	325
18	51000	322	469	145	22415	310
19	49157	266	405	122	20260	295
20	47434	220	351	99	18313	280
21	45760	184	306	82	16554	270
22	44247	153	268	69	14965	260
23	42880	129	235	59	13529	250
24	41645	108	208	51	12231	245
25	40528	91	184	45	11058	235
26	39519	77	163	39	9998	225
27	38607	66	145	34	9040	215
28	37782	56	130	30	8173	205
29	37037	48	116	27	7390	195
30	36363	41	104	24	6683	180
31	35754	35	94	21	6043	170
32	35203	30	85	19	5464	155
33	34705	26	77	17	4941	140
34	34255	22	69	15	4468	120
35	33848	19	63	14	4041	110
36	33480	16	57	13	3654	83
37	33147	14	52	12	3305	68
38	32846	12	47	11	2989	55
39	32574	11	43	10	2703	45
40	32328	9	39	9	2444	37
41	32105	8	36	8	2211	30
42	31904	7	33	7	1999	25
43	31722	6	30	6	1808	21
44	31557	5	28	5	1635	18
45	31409	5	25	5	1479	15
46	31274	4	23	4	1338	13
47	31152	3	22	4	1210	11

48	31042	3	20	4	1094	9
49	30943	3	18	3	990	8
50	30853	2	17	3	895	7
51	30771	2	16	3	810	6
52	30697	2	14	2	732	5
53	30631	2	13	2	662	4
54	30571	1	12	2	599	3
55	30516	1	11	2	542	3
56	30467	1	11	1	490	2
57	30422	1	10	1	443	2
58	30382	1	9	1	401	1
59	30346	1	8	1	363	1
60	30328	1	8	1	328	1

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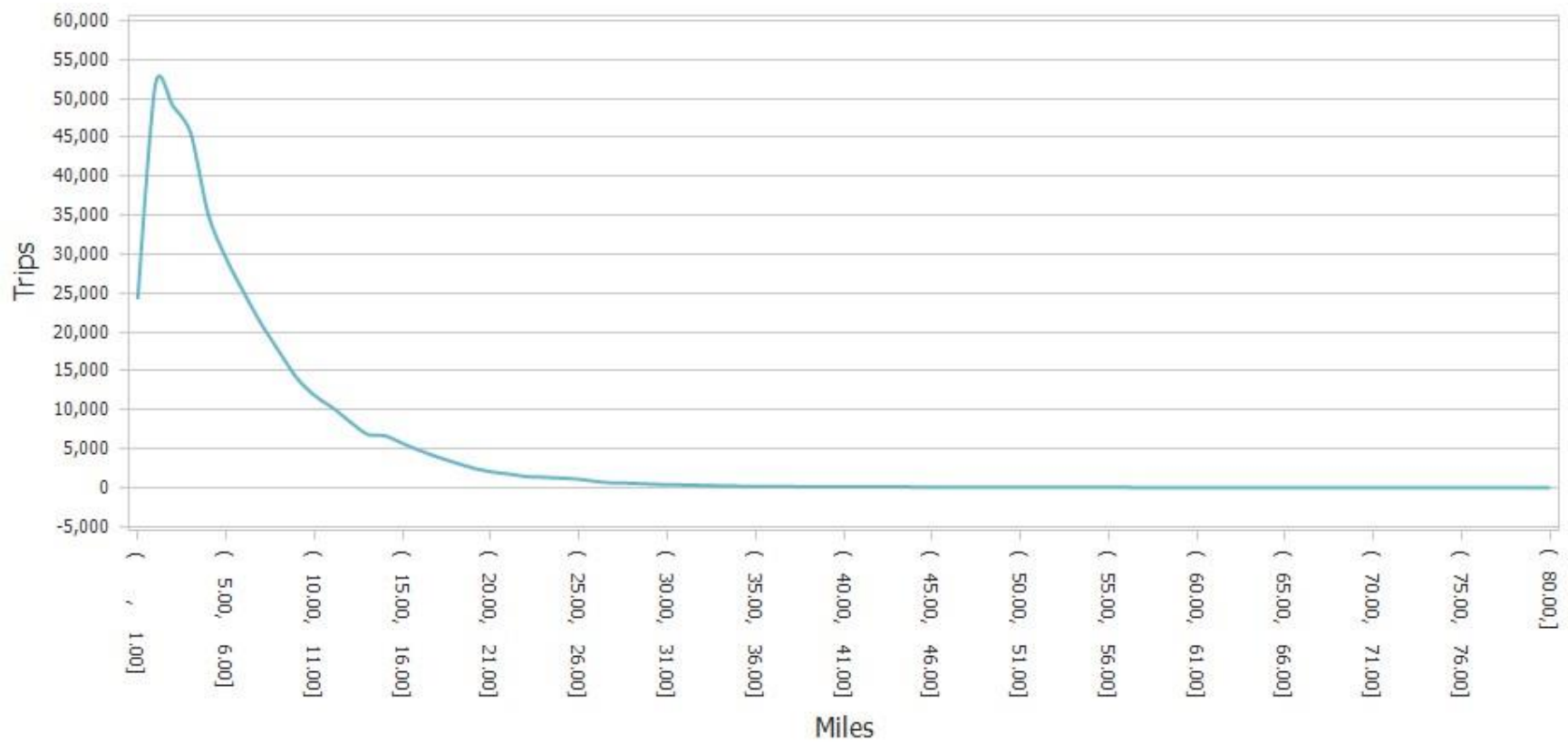
Figure 2 Home Based Work Trip Length Distribution



Average Trip Length: 19.402
Maximum Trip Length: 81.383
Minimum Trip Length: 0.097

HBW Trip Length Distribution

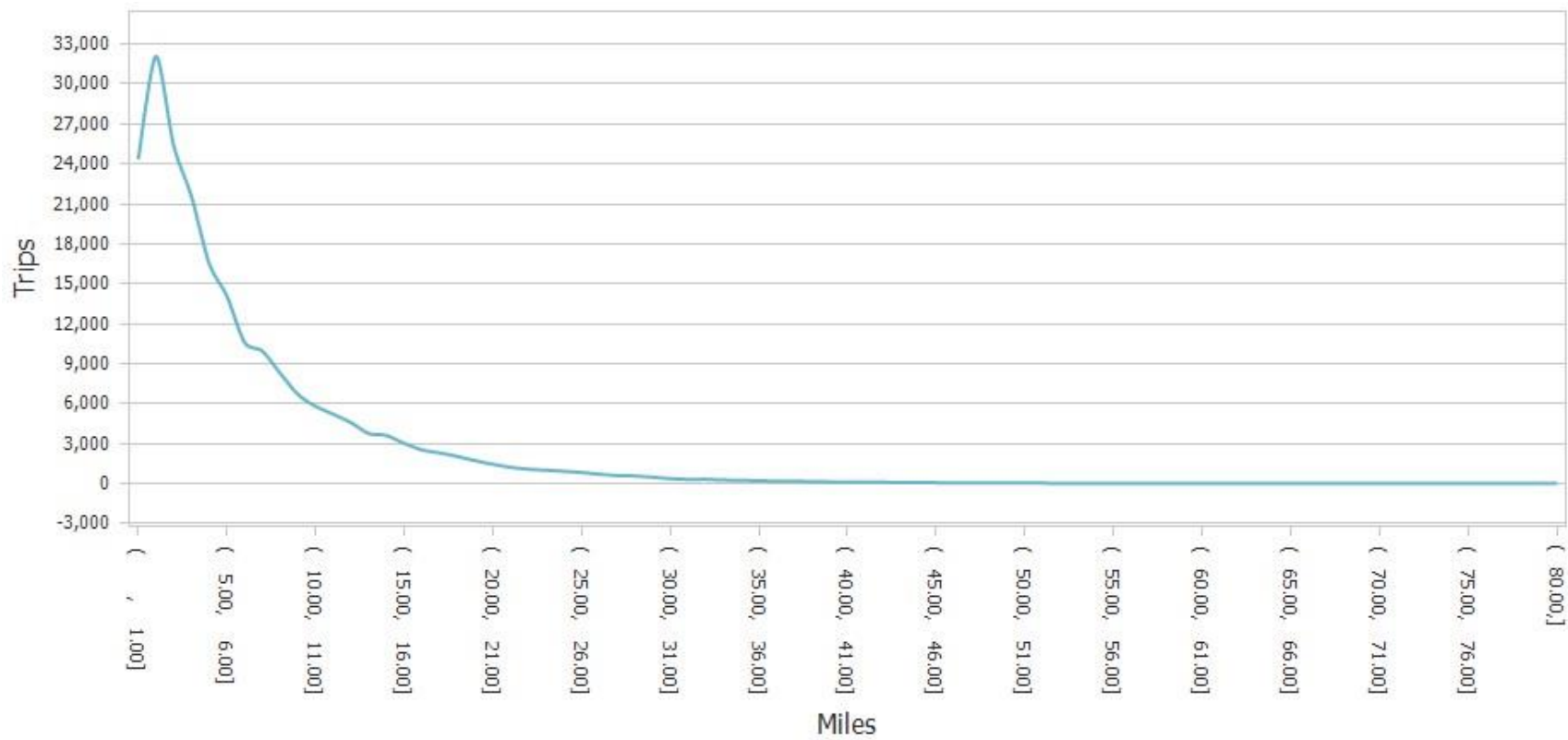
Figure 3 Home Based Other Trip Length Distribution



Average Trip Length: 6.558
Maximum Trip Length: 81.524
Minimum Trip Length: 0.097

HBO Trip Length Distribution

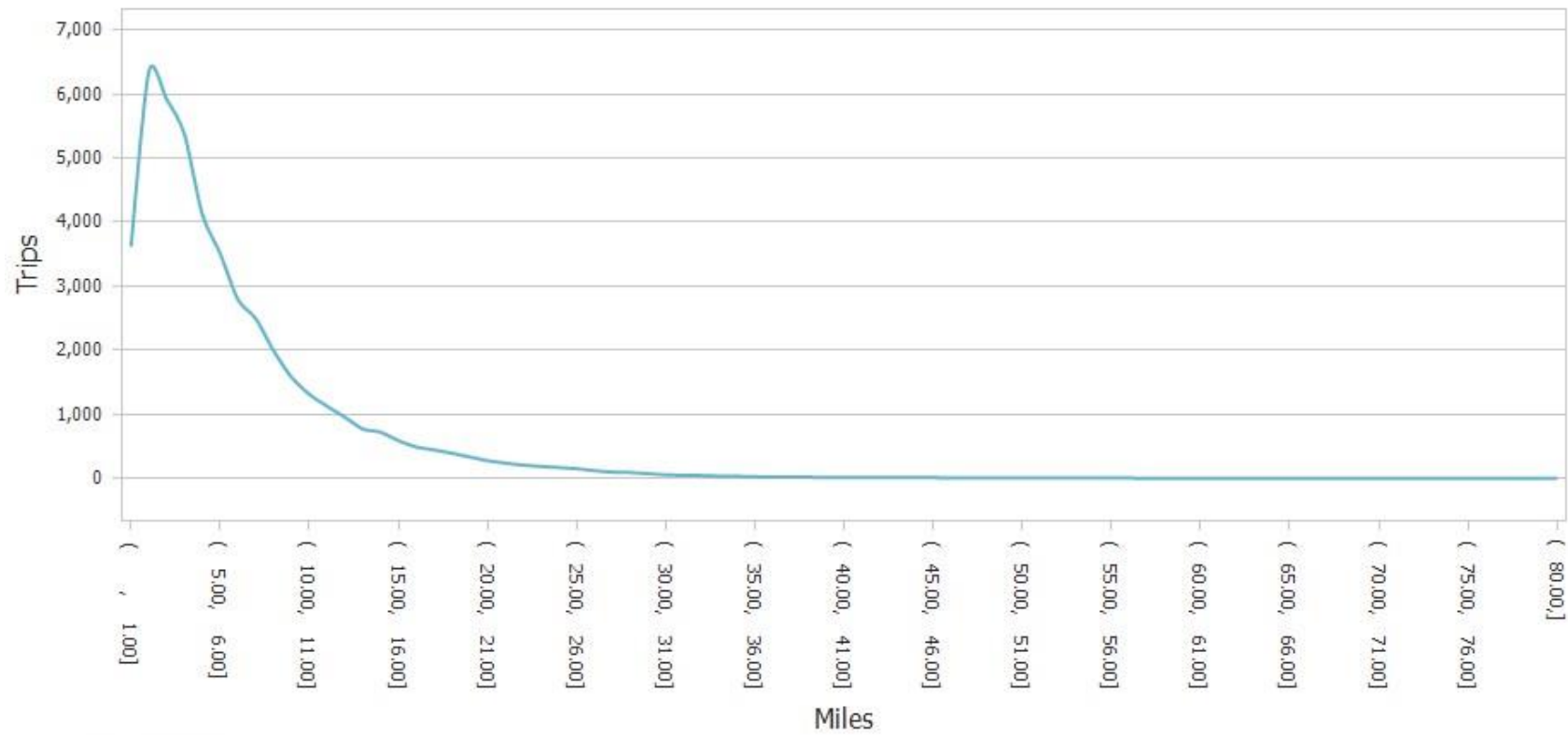
Figure 4 Non Home Based Trip Length Distribution



Average Trip Length: 6.635
Maximum Trip Length: 81.524
Minimum Trip Length: 0.058

NHB Trip Length Distribution

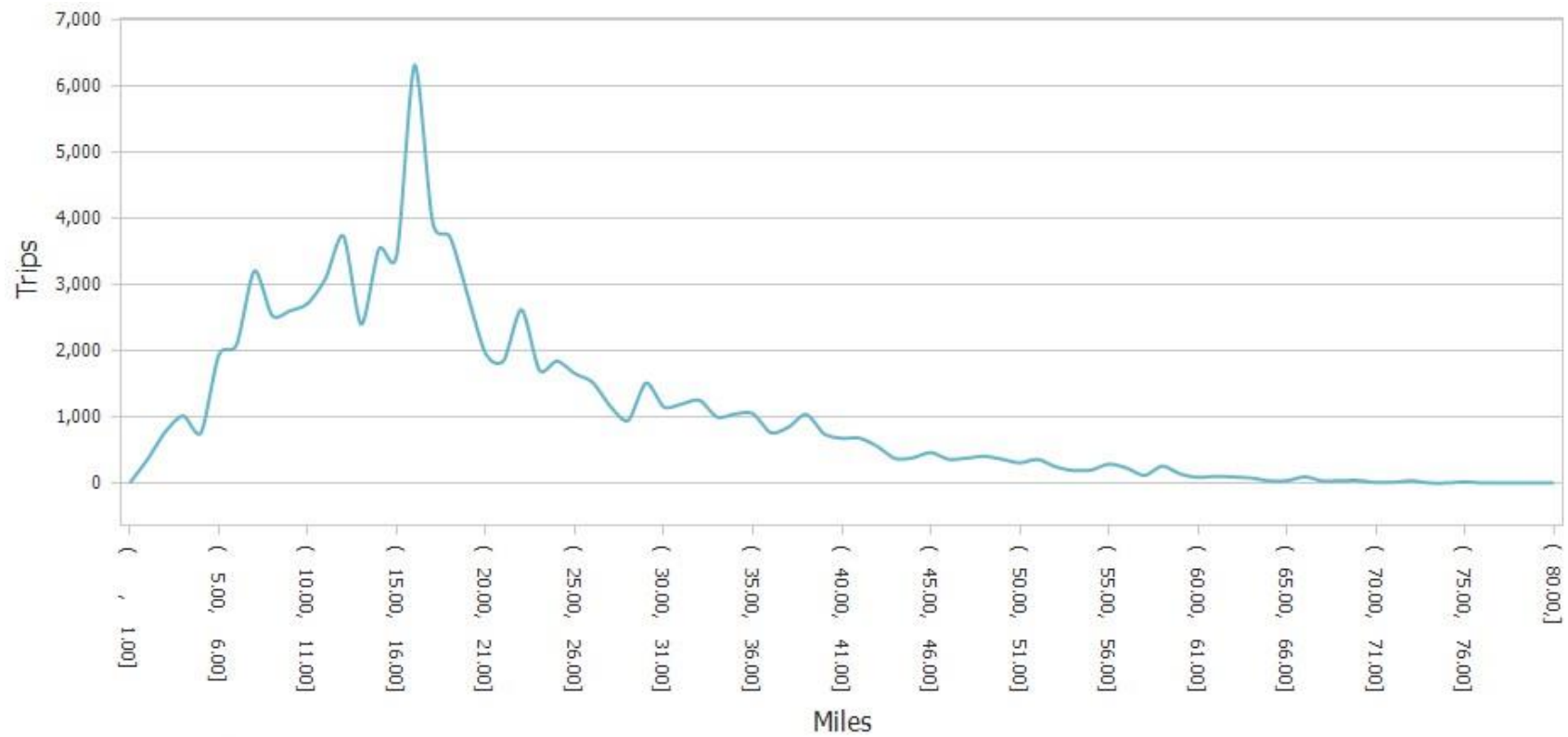
Figure 5 Truck and Taxi Trip Length Distribution



Average Trip Length: 6.497
Maximum Trip Length: 81.524
Minimum Trip Length: 0.058

TKT Trip Length Distribution

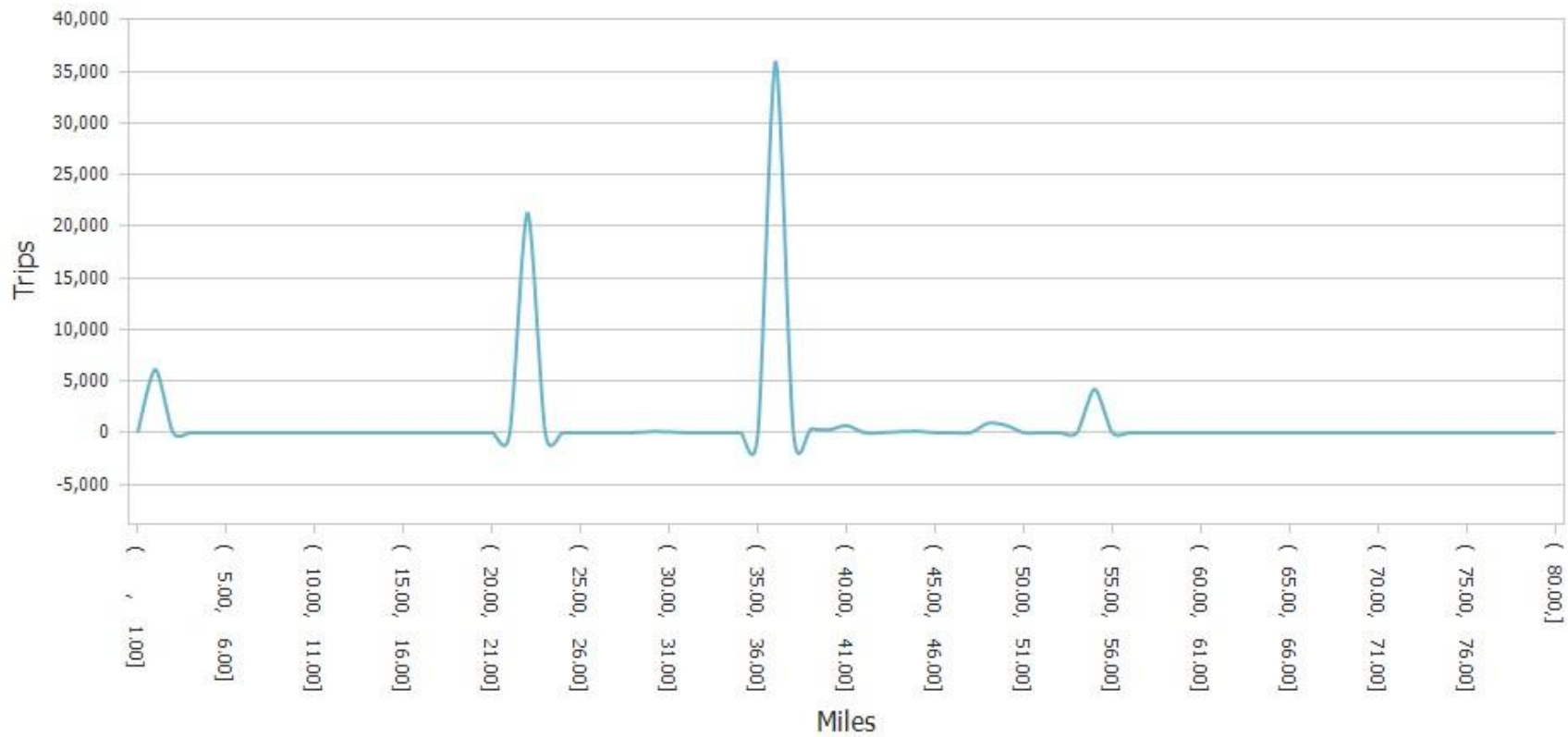
Figure 6 Internal External Trip Length Distribution



Average Trip Length: 20.842
Maximum Trip Length: 76.171
Minimum Trip Length: 0.623

IX Trip Length Distribution

Figure 7 External External Trip Length Distribution



Average Trip Length: 30.801
Maximum Trip Length: 73.68
Minimum Trip Length: 1.233

XX Trip Length Distribution

Parameters

Travel Demand Model (TDM) for Baldwin County depends on various components to produce projected volumes. It needs:

- A Highway Network- geographic representation of the roads in the area with speeds and capacities based on land use and functional classification.
- Traffic Analysis Zones (TAZ)- a spatial boundary generally following census tracts and/or natural boundaries.
- Socio economic data- Population, households, employment, school enrollment for the base year 2020 and future data 2050.

Highway Network

The Baldwin County highway network was built from the July, 2021 Functional Classification map (Figure 8) provided by ALDOT. This includes portions of the ESMPO network that was migrated from CUBE to TransCAD. At a minimum, the ESRI Shapefile provided a line feature which provided distance and the functional classification of the feature for every functionally classified road in Baldwin County. The TransCAD network for Baldwin County is representative of 2021. Of note, there have been several changes made to the Functional Classification of the Baldwin County road network since 2021, and those are reflective in the 2050 Existing and Committed Network. Examples include CR-49, CR-32, Milton Jones Road, Section Street, and Langford Road.

When the July, 2021 Functional Classification Map was created by ALDOT, it was done using a CAD software in that the lines did not typically have to “snap” to one another. Snapping forces features to align precisely with other features or specific geometric locations during editing or digitizing and prevents gaps or overlaps between features. This is crucial for a TransCAD network. TransCAD requires the connectivity of snapped line segments, and this was major cleanup of line features that had to be done to utilizing several features of TransCAD.

The network includes Interstate 65 and Interstate 10, principal arterials including US routes and State Routes (SR) US-31, US-90, US-98, SR-59, SR-104, SR-161, SR-180, SR-181, SR-182, SR-225, SR-287, minor arterials, major collectors, and minor collectors. All principal arterials within Baldwin County are state routes. Figure 9 is the map of the Baldwin County Network displaying the functional classification used for the model’s network.

Local Streets

Streets that are functionally classified as “local”, are not included in the travel demand forecast network. The trips from the Traffic Analysis Zones (TAZs) are applied to the network via centroid connectors, rather than local streets. The centroid connectors are imaginary lines in the network representative of the local roads. They are connected to the TAZ centroid, and each TAZ can have between 1-4 centroid connectors. Figure 10 displays an example of the Centroid Connectors for the Baldwin County network.

Figure 8 ALDOT 2021 Functional Classification Map

BALDWIN COUNTY HIGHWAY FUNCTIONAL CLASSIFICATION SYSTEM

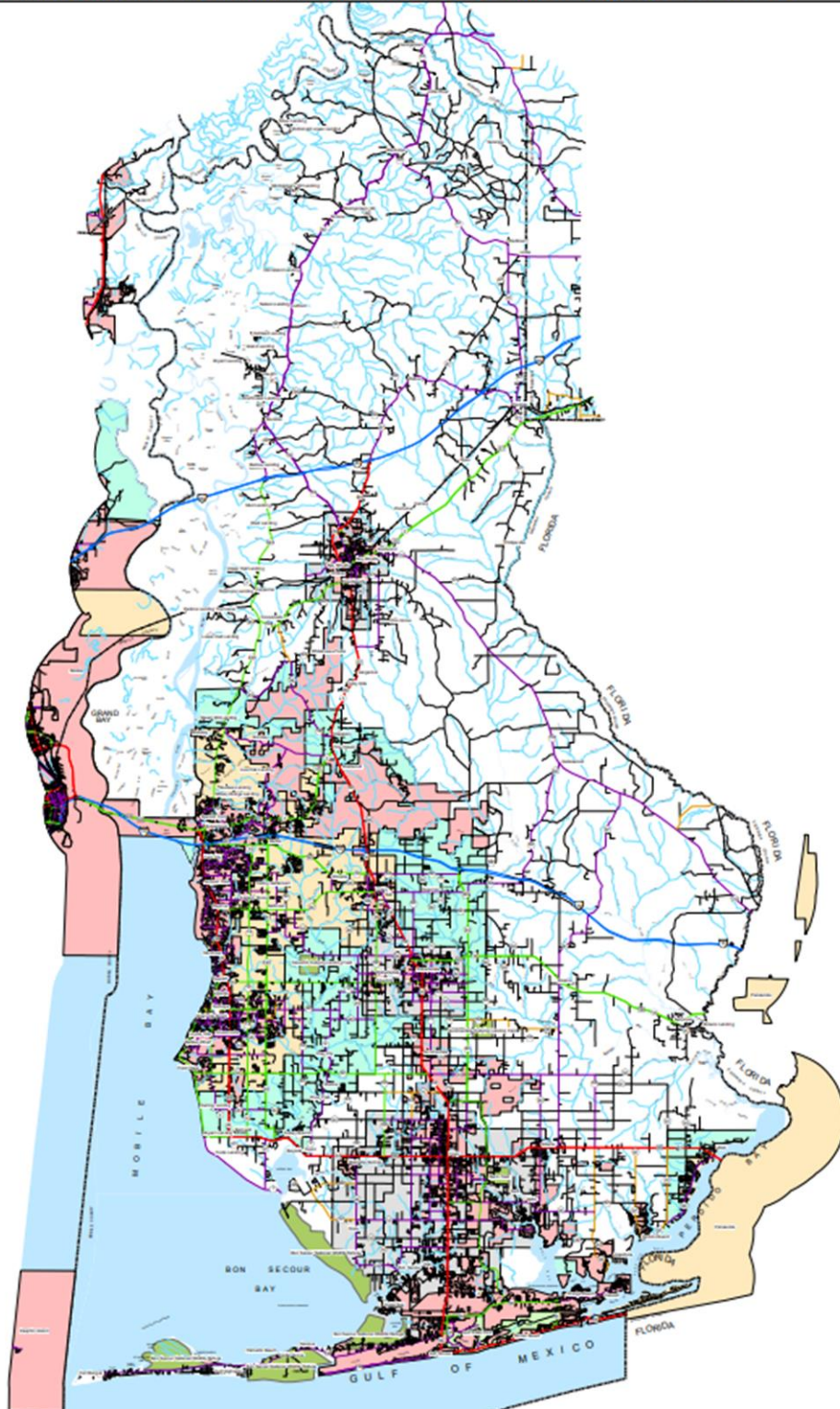
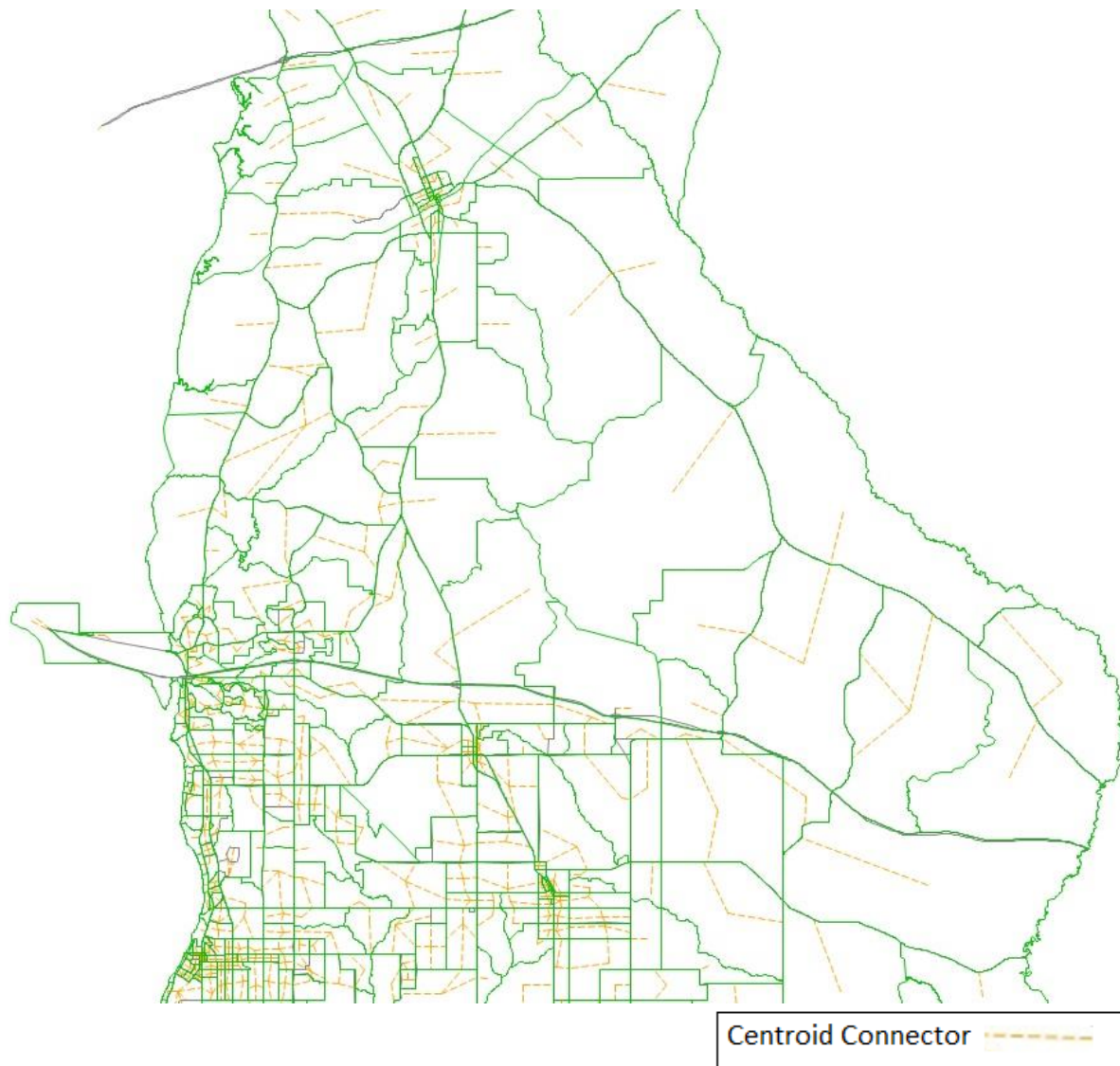


Figure 9 Base year Functional Classification



Figure 10 Example of Baldwin County Centroid Connectors



Speeds and Capacities

The model utilizes speed and capacity look-up tables to automatically calculate road segment (link) capacities and speeds in real-time. Initially based on the road's functional class and number of lanes (Table 2), capacities are further refined by factoring in directionality, median type, and area density type (planning area). Speeds by Planning Area (Table 3) are directly related to the capacity of a roadway. Capacities (Table 4) are expressed as vehicles per day per direction. Depending on the functional classification of a road and the planning area of which the road is in, the speed and capacity may vary. That is to say that a minor arterial speed and capacity in an urban area will be different than the speed and capacity of a minor arterial in a rural area. Speeds and capacities are a critical component of the model, influencing both its operation and network analysis.

TransCAD uses coding (Table 2) in that each link in the network is coded per facility type based on functional classification, the number of lanes, whether it is divided, and if it is a one-way road.

Table 2 Facility Codes

#	<u>Link</u>		<u>Facility</u>		# of lanes
	<u>group</u>	<u>FC</u>	<u>type</u>	<u>Divided</u>	
1	11	Freeway	1	1	4
2	32	Divided Principal Arterial	3	1	4
3	35	Undivided Principal Arterial	3	0	2
4	36	Undivided Principal Arterial	3	0	4
5	42	Divided Minor Arterial	4	1	4
6	45	Undivided Minor Arterial	4	0	2
7	46	Undivided Minor Arterial	4	0	4
8	54	Undivided Collector	5	0	2
9	61	One-Way Principal Arterial	6	0	2
10	91	Ramp	9	0	1
11	99	Centroid Connector	99	0	0

Speeds and capacities are coded to the network based on Planning Area and functional classification of the road. The following speeds in Table 3 are coded to the link when the model is run, per type of facility and urban density code.

Table 3 Speeds of Baldwin County Network

<u>Fgroup</u>	<u>Urban</u>	<u>Suburban</u>	<u>Fringe</u>	<u>Rural</u>	<u>Description</u>
1	55	59	60	64	Freeways
2	53	56	60	62	Expressways
3	35	45	54	59	Principal Arterials
4	30	39	39	44	Minor Arterials
5	30	35	40	50	Collectors
6	30	37	40	45	One-way Principal Arterials
7	25	30	35	40	One-way Minor Arterials
8	22	27	27	32	One-way Collectors
9	35	35	37	40	Ramps
99	14	17	18	20	Centroid Connectors
11	5	5	5	5	Toll

Capacities are crucial to the network. As the volume approaches capacity on a link in the network, the speed will decrease. This changes the path of zonal trip patterns where the time is the critical steering factor for trips.

Table 4 Capacities of the Baldwin County Network

Fgroup	Urban	Suburban	Fringe	Rural	Description
100	17000	17000	17000	17000	freeways
200	12500	12500	12500	12500	expressways
311	9250	11000	12500	11250	principal - divided - 1 lane
312	7300	8475	9225	8125	principal - divided - 2 lanes
313	7633	8333	8333	8333	principal - divided - 3 lanes
314	7813	9200	7963	7963	principal - divided - 4+ lanes
301	8300	8900	11600	8750	principal - undivided - 1 lane
302	7000	7750	7750	7750	principal - undivided - 2 lanes
303	6350	7633	7150	7150	principal - undivided - 3 lanes
304	6700	7888	7138	7138	principal - undivided - 4+ lanes
411	8750	10500	12000	12000	minor - divided - 1 lane
412	7000	7975	7975	7975	minor - divided - 2 lanes
413	7033	7600	7600	7600	minor - divided - 3 lanes
414	7033	7600	7600	7600	minor - divided - 4+ lanes
401	8300	8900	11600	8750	minor - undivided - 1 lane
402	6000	6850	6850	6850	minor - undivided - 2 lanes
403	6000	6850	6850	6850	minor - undivided - 3 lanes
404	6000	6850	6850	6850	minor - undivided - 4+ lanes
511	8150	10400	11600	11600	collector - divided - 1 lane
512	6550	7125	7750	6825	collector - divided - 2 lanes
513	6850	7000	7000	7000	collector - divided - 3 lanes
514	6850	7000	7000	7000	collector - divided - 4+ lanes
501	7150	8300	8900	8900	collector - undivided - 1 lane
502	4900	6550	6550	6550	collector - undivided - 2 lanes
503	4900	6550	6550	6550	collector - undivided - 3 lanes
504	4900	6550	6550	6550	collector - undivided - 4+ lanes
601	7500	8550	8550	8550	one-way principal - 1 lane
602	7500	8550	8550	8550	one-way principal - 2 lanes
603	7500	8533	8533	8533	one-way principal - 3 lanes
604	7500	8533	8533	8533	one-way principal - 4+ lanes
701	6000	7050	7000	7000	one-way minor - 1 lane
702	6000	7050	7000	7000	one-way minor - 2 lanes
703	5267	6500	6000	6000	one-way minor - 3 lanes
704	6375	6500	6000	6000	one-way minor - 4+ lanes
801	4500	5650	5600	5600	one-way collector - 1 lane
802	4500	5650	5600	5600	one-way collector - 2 lanes
803	4200	5200	4800	4800	one-way collector - 3 lanes
804	5100	5200	4800	4800	one-way collector - 4+ lanes
900	9000	9000	9000	9000	Ramps
999	99999	99999	99999	99999	centroid connectors
1112	1000	1000	1000	1000	Toll

Planning Areas

An important part of the travel demand model is how the land use reacts to speed. As development occurs creating more conflict points, access to the roadways, and visual distractions, the speeds are reduced reducing the capacity of the roadway. These planning areas are merely a reflection of density. They are the employees, households, and school enrollment divided by the acreage. The Planning Areas are divided into nine areas as shown in Table 5. For coding in terms of capacity and speed for network refinement in the TransCAD model, the planning areas are categorized as Urban, Suburban, Fringe and Rural.

Table 5 Planning Area Classification

1	CBD	Major CBD	1	Urban
2	CBD	Minor Downtown	1	Urban
3	CBD	Fringe Areas adjacent to a downtown	1	Urban
4	Urban	Stable Established residential areas	2	Suburban
5	Urban	Activity Center Suburban business districts	2	Suburban
6	Urban	Growth Recent/ongoing suburban residential	2	Suburban
7	Urban	Transitioning Growth next to/outside urban boundary	2	Suburban
8	Rural Developed	Small cities outside transitioning area	3	Fringe
9	Rural Undeveloped	Undeveloped areas/outside MPO area	4	Rural

Figure 11 is a map of the TAZ's planning area for Baldwin County for the base year, and Figure 12 is a map of the TAZ's planning area for Baldwin County for the future year. Comparing Figure 11 and Figure 12 can give a sense of how the County is expected to grow in the next 25 years. Figure 13 is the Planning Areas being applied to the Base year network. Each link is coded with its respective Planning Area. If a link in the network is the border of two planning areas, the link is coded with the higher of the two Planning Areas.

Figure 11 Base Year Planning Areas

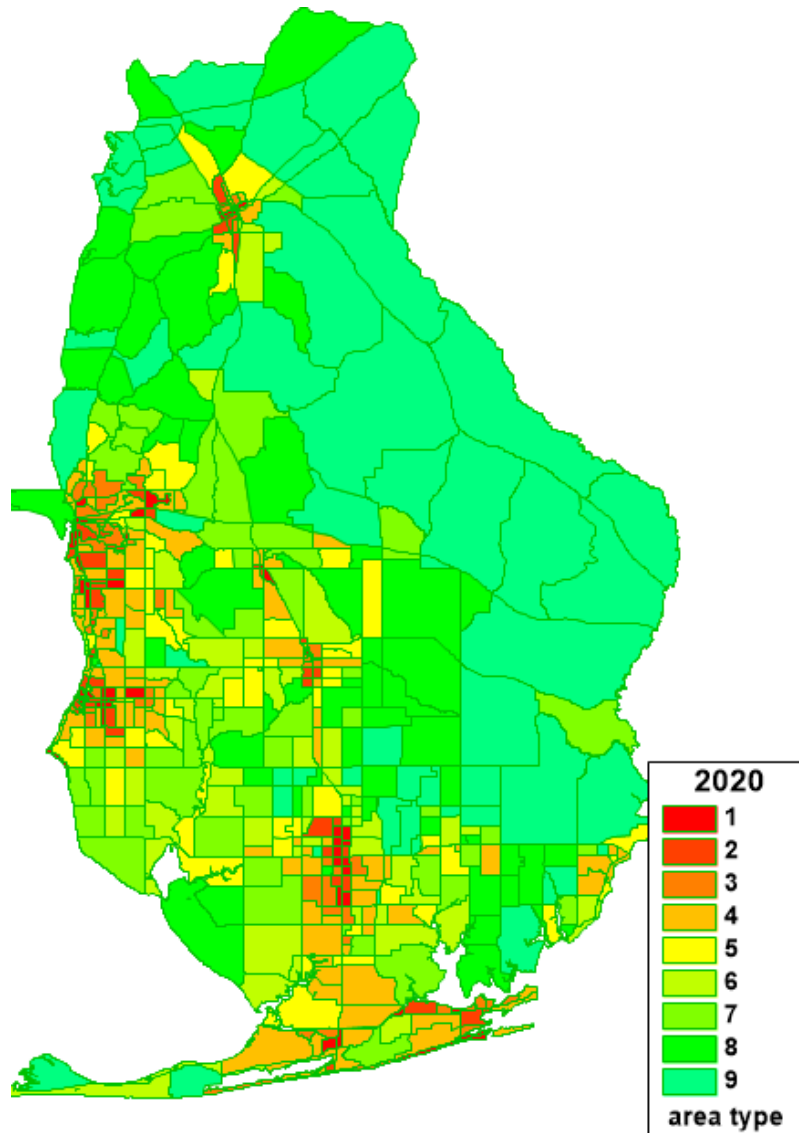


Figure 12 Future year Planning Areas

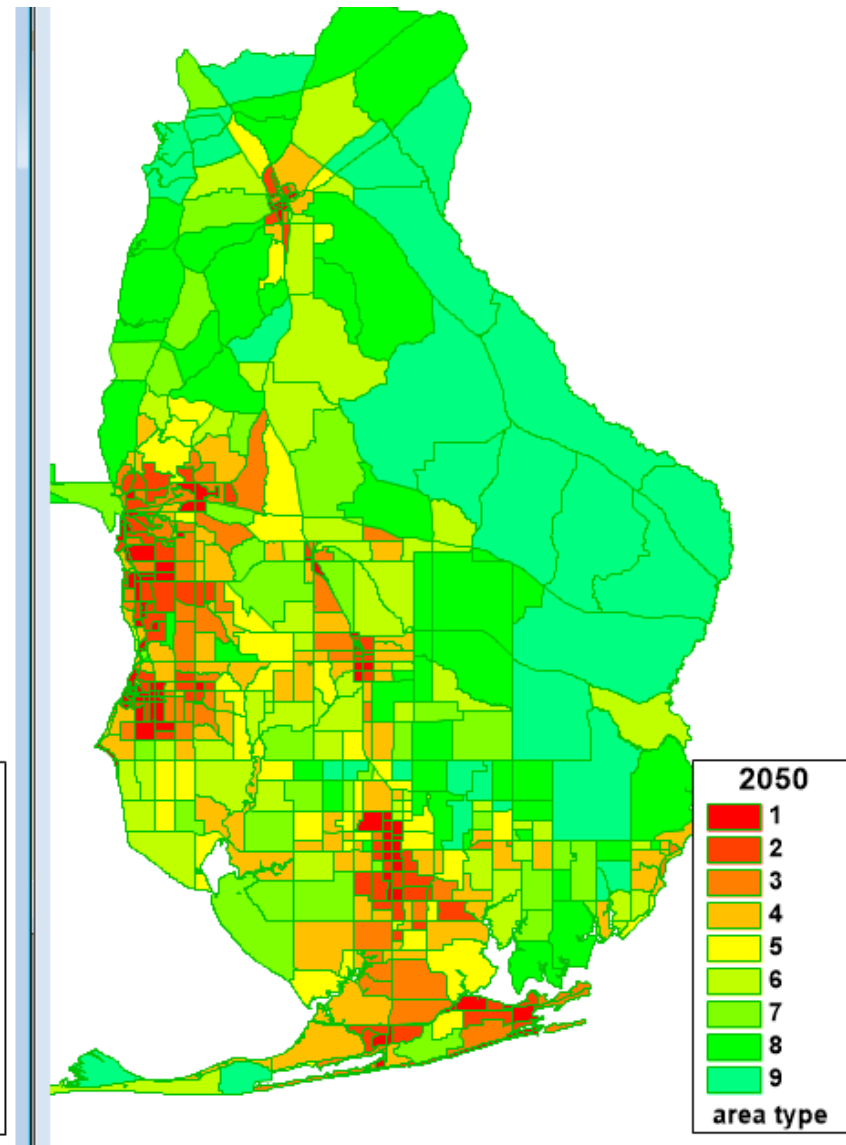
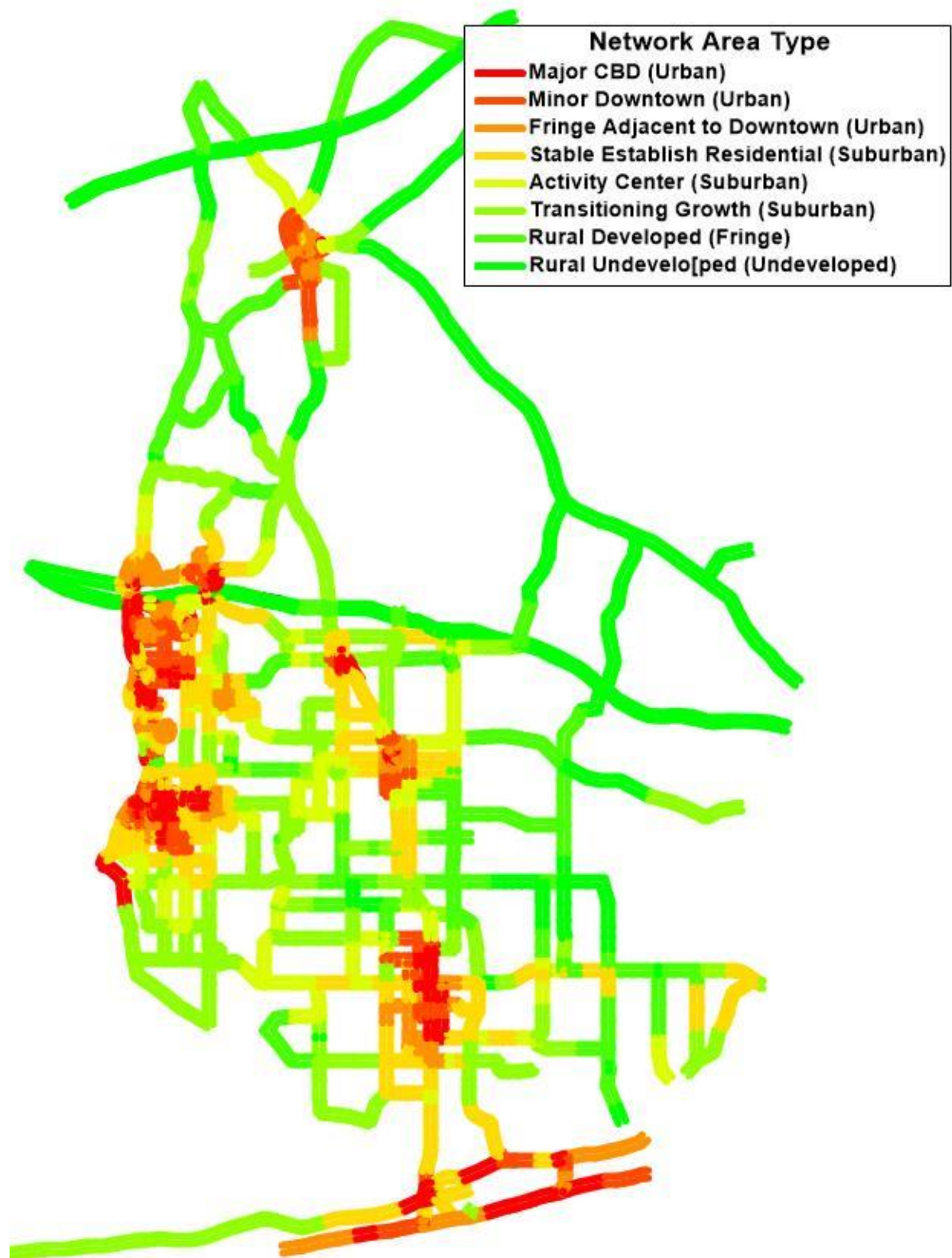


Figure 13 Network Coding of Planning Area



Traffic Analysis Zones

The primary input into the travel demand model is the socio-economic data; demographic files which include the population, households, employment, and school enrollment estimates for existing and future conditions. The data is collected for the base year and is assigned to the respective Traffic Analysis Zone (TAZ). Each TAZ will have an existing number of employees, households, and population for the base year, and future year. For the base year, the socioeconomic data is input into the 4-step travel demand model (TDM), and the output is a simulated traffic volume to be validated against the existing Average Annual Daily Traffic (AADT) counts collected by ALDOT. Once the base year TDM is validated to the AADT and closely matches the traffic counts, the socio-economic data is forecasted for the year 2050. The model is rerun using the forecasted socio-economic data, and it provides a snapshot as to which roads most likely will be over capacity in the future year. The key is making sure that there is good initial data, and good data used to estimate the forecasted socio-economic data.

Baldwin County is broken into 592 internal TAZs. Existing population and household data per TAZ was derived from US Census data.

There are 12 external TAZs in Baldwin County. External TAZs do not have a geographic representation but are merely the point of which the network link ends on a road that crosses the border of the County. The Bay Way (I-10) and the Causeway (US-90) for example are external zones and are represented by a centroid connector as the roads enter the county.

Socio-economic Data

Base Year Data

The household and population data came from the 2020 Census, aggregated to the TAZs. The employment data was purchased from a company called Data-Axle and provides types of employees such as retail and non-retail for the base year. The existing employment data included XY coordinates of business, the type of business (NAICS code) and the number of employees for 2021, and 2023. Because of COVID and how it affected the landscape in terms of where employees reported to work, 2021 employment data was verified with data from 2023. The data was checked for accuracy as there were some errors in the employment data purchased.

Since 2015, there was an increase in non-retail employees overall, and a decrease in retail employees in some parts of the County, while an increase in other parts of the County. COVID has made some permanent changes regarding where employees work, and services like Amazon, Walmart and other delivery shopping have affected the local retail number of employees. Although restaurants are considered a service industry by the North American Industry Classification System (NAICS) code, for the purposes of this plan they are retail employees.

Figure 14 Existing Households by TAZ

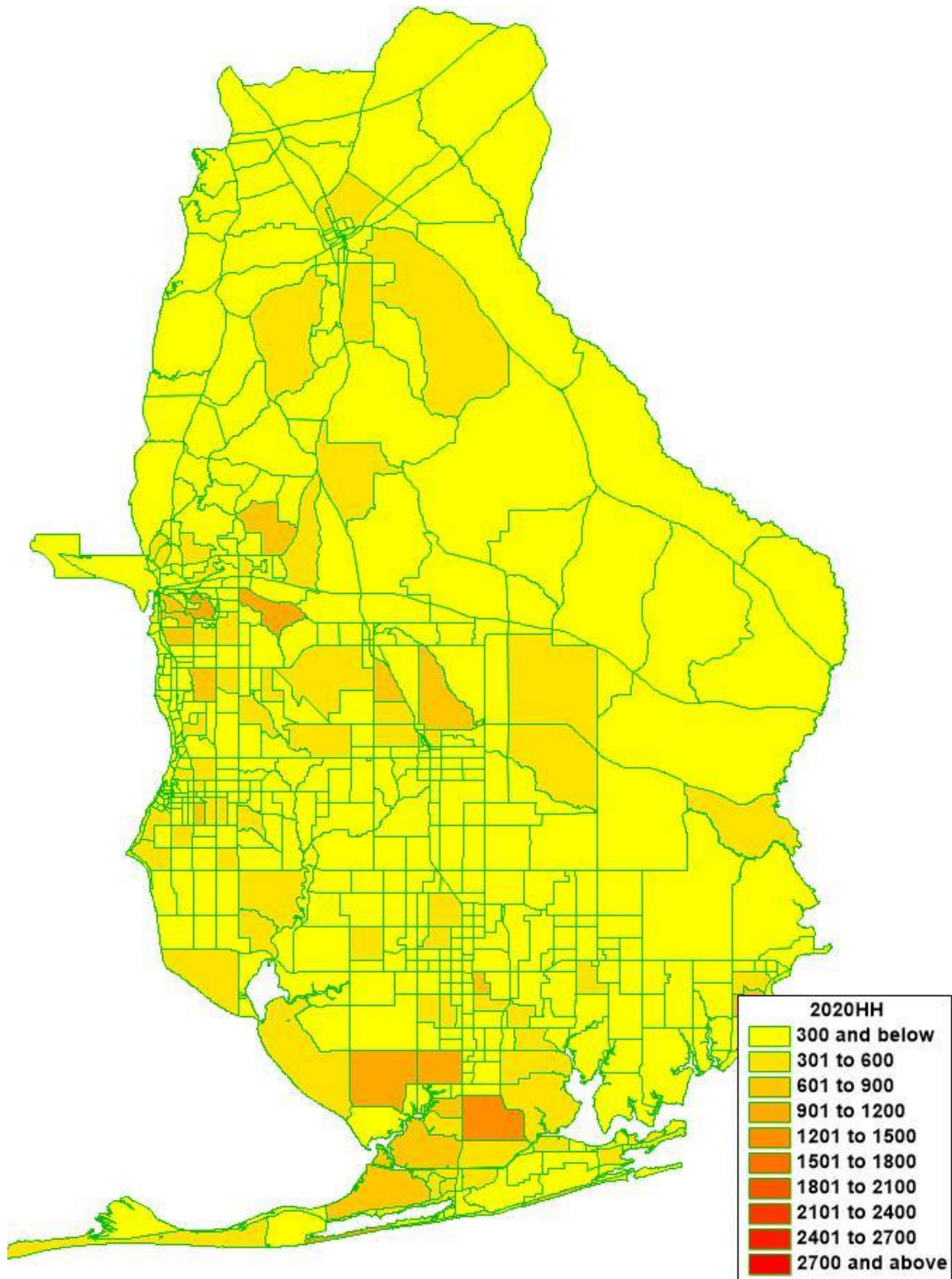


Figure 15 Existing Retail Employment by TAZ

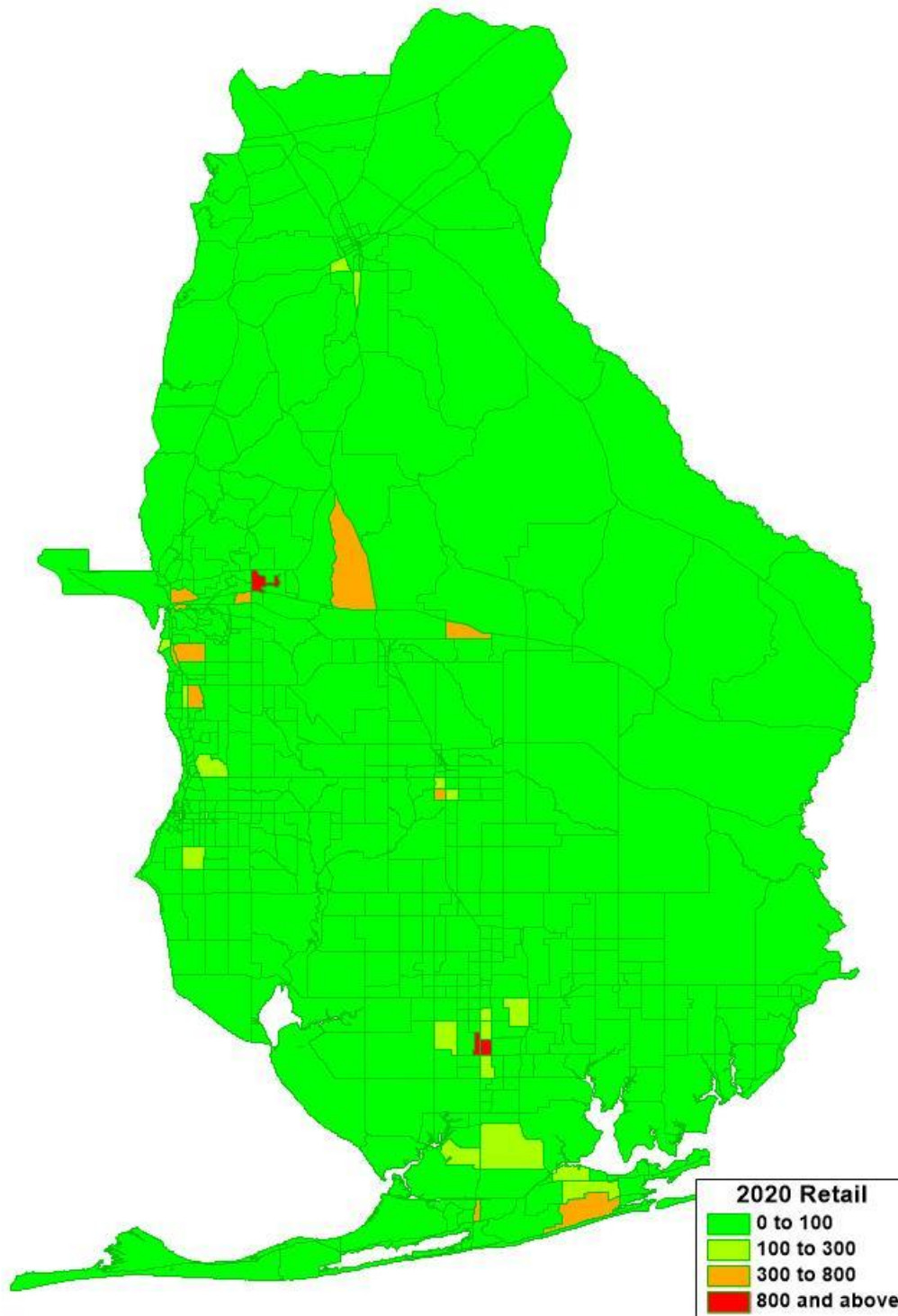
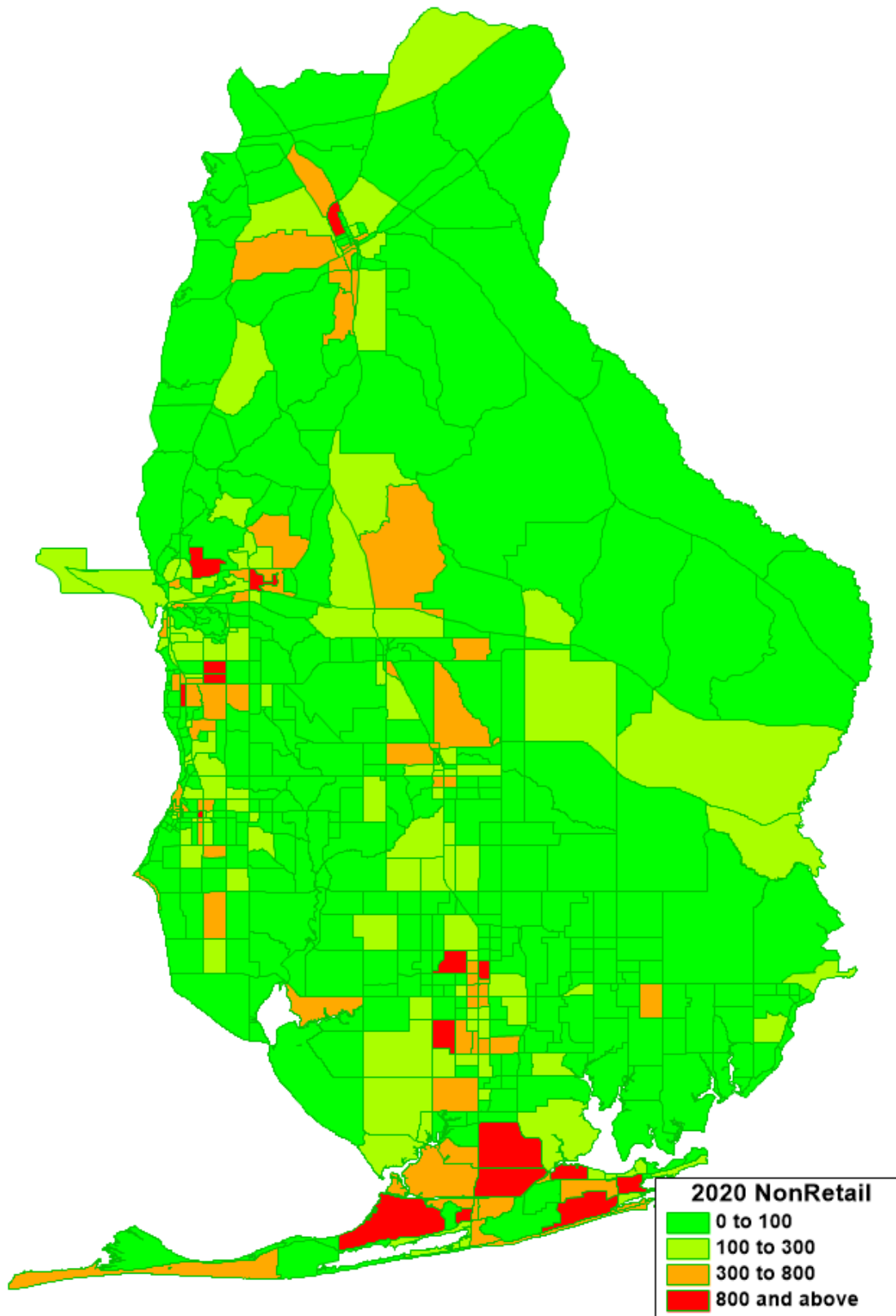


Figure 16 Existing Non-Retail Employment by TAZ



2010 retail and non-retail employees were not available for comparison. Figure 14-16 is the base year socio economic data by TAZ and Table 6 identifies the base year and future year (2050) socio-economic data for Baldwin County.

Table 6 Base Year and Future Socio-Economic Data

	Baldwin County	
	2020(2021)	2050
Population	226,974	488,000
Households	93,782	199,415
Retail	26,649	44,656
Non-Retail	80,479	133,970

Trip Generation

In trip generation, the number of trips per TAZ are estimated by using trip rates that are applied to the socio-economic data. This data includes rates for trip productions and trip attractions. Trip production rates are sensitive to the number of people and vehicles per household. The trip attraction rates are sensitive to the type of employee that is housed. For example, a retail employee produces more trips than manufacturing employees. An establishment with ten retail employees will attract much more trips than a manufacturer with ten employees.

The function of trip generation is to take land use data, determine the number of trips produced by each zone, determine the number of trips attracted by each zone, and balance the total attractions and productions. Trips are produced for each zone through trip rates that are sensitive to household income. Household income is provided the US Census and averaged for each TAZ. In this model, there are 6 income levels for Baldwin County. Table 7 shows that as income level increases, vehicles per household increases, as does the number of trips per household. 1 being is lowest income level, 6 is the highest income level. Table 8 is the percentage of vehicles per household by income level. Trips are produced and attracted to other TAZs by various trip purposes. For the Baldwin County model the internal trips that are produced by the Trip Generation step are for the trip purposes Home Based Work (HBW), Home Based Other (HBO), Non-Home Based (NHB), Truck and Taxi trips (TKT), Internal -External Trips (IE).

Table 7 Trips per Household Income by Veh/HH

<u>Income</u>	<u>Zero cars</u>	<u>1 car</u>	<u>2 cars</u>	<u>3 or more</u>
1	0.9	3.6	6.7	8.3
2	1.8	5.3	8.3	10.1
3	3.5	7.5	10	11.9
4	2.9	7.6	10.4	12.2
5	2.2	7.9	10.8	12.6
6	1.6	8.1	11.3	13

Table 8 Percent of vehicles per HH by Income level

Income	autoPCT	autoPCT1	autoPCT2	autoPCT3
1	0.14	0.56	0.21	0.091
2	0.13	0.51	0.25	0.11
3	0.11	0.46	0.29	0.14
4	0.09	0.41	0.32	0.18
5	0.08	0.36	0.37	0.19
6	0.07	0.33	0.37	0.23

Trip attractions are generally places of employment. Attractions are estimated based on the trip generation characteristics of the land-uses within the TAZs, and (like productions) are broken out by trip purpose. The trip attraction rates in this model were primarily derived from the rates provided in NCHRP 716 as well as other travel demand models for smaller urban areas. They were adjusted during the validation phase to reflect local trip-making characteristics and to more closely match the calibrated trip productions.

The trips productions and attractions are converted to origin and destinations by the gravity model during trip distribution. Skipping the public transit mode (mode choice), trips per TAZ are assigned to specific routes to move from origin to destination in the assignment process. Lastly, capacity restraint curves are applied to react to congestion of the network; as volume to capacity ratio increases, the speeds in the model decrease.

Capacity Restraint

Without any regard to capacity, when the trips are applied to the network it is considered a “free flow” network. This is not realistic as travel behavior changes when congestion occurs. The shortest, logical trip of each trip pair from origin to destination is the goal of the model. Not until the capacity restraint curve is applied to the loaded network is it considered a capacity restrained assignment. Some networks will use separate capacity restraint curves per each functional classification. Most demand forecasting models apply volume-delay functions (VDF), which are the relationship between speed and the volume-to-capacity (v/c) ratio such as the Bureau of Public Roads (BPR) equation (Bureau of Public Roads 1964). The BPR curve is the standard, default capacity restraint curve for the software TransCAD. The general form of the BPR function used for volume-delay is the formula in Figure 17.

Figure 17 BPR Capacity Restraint Curve

$$\text{Congested Travel Time} = \text{Free-Flow Travel Time} \times \left(1 + \alpha \times \left(\frac{\text{Volume}}{\text{Capacity}}\right)^\beta\right)$$

For freeways, Alpha (α) = 0.83 and Beta (β) = 5.50. For other facilities (e.g., arterials, multilane highways): Alpha (α) = 1.00 and Beta (β) = 5.40

Model Validation

The Alabama Department of Transportation conducted 2021 Average Annual Daily Traffic Counts (AADT) at count stations for the majority of roads on the federal aid system within Baldwin County. 2020 was not used because the travel behaviors throughout Baldwin County were skewed due to COVID. The TDM input is data as noted above for year 2021, the output is a simulated volume to be compared to the AADT. Model “validation” happens when the simulated trips, or volume, produced by the model matches (to within federal parameters) to the Average Annual Daily Traffic Counts (AADT). The base year model (2020-2021) is validated within federal standards to 2021 AADT. One of the validation techniques is called a screen line comparison.

The base year model (2020-2021) is validated within federal standards to 2021 AADT. The total Vehicle Miles Traveled (VMT) for the Baldwin County model has a 0% error. The links in the network that have a 2021 AADT traffic count, have a combined (VMT) of 3,232,621. Those same links have a modeled VMT of 3,230,065. The error limit per functional classification is within acceptable parameters. Figure 20 is the error limit for the functionally classified roads within Baldwin County.

Screenlines

A screen line is an imaginary line that traverses a region of a network for comparative reasons. It is imperative that when the screen line volumes are compared to the traffic counts (AADT) they are within federal limits. Figure 18 shows the percent error per screenline as compared to the limit of error allowed. There are 12 screen lines in the Baldwin County network Figure 19.

Figure 18 Screenline Error for Baldwin County

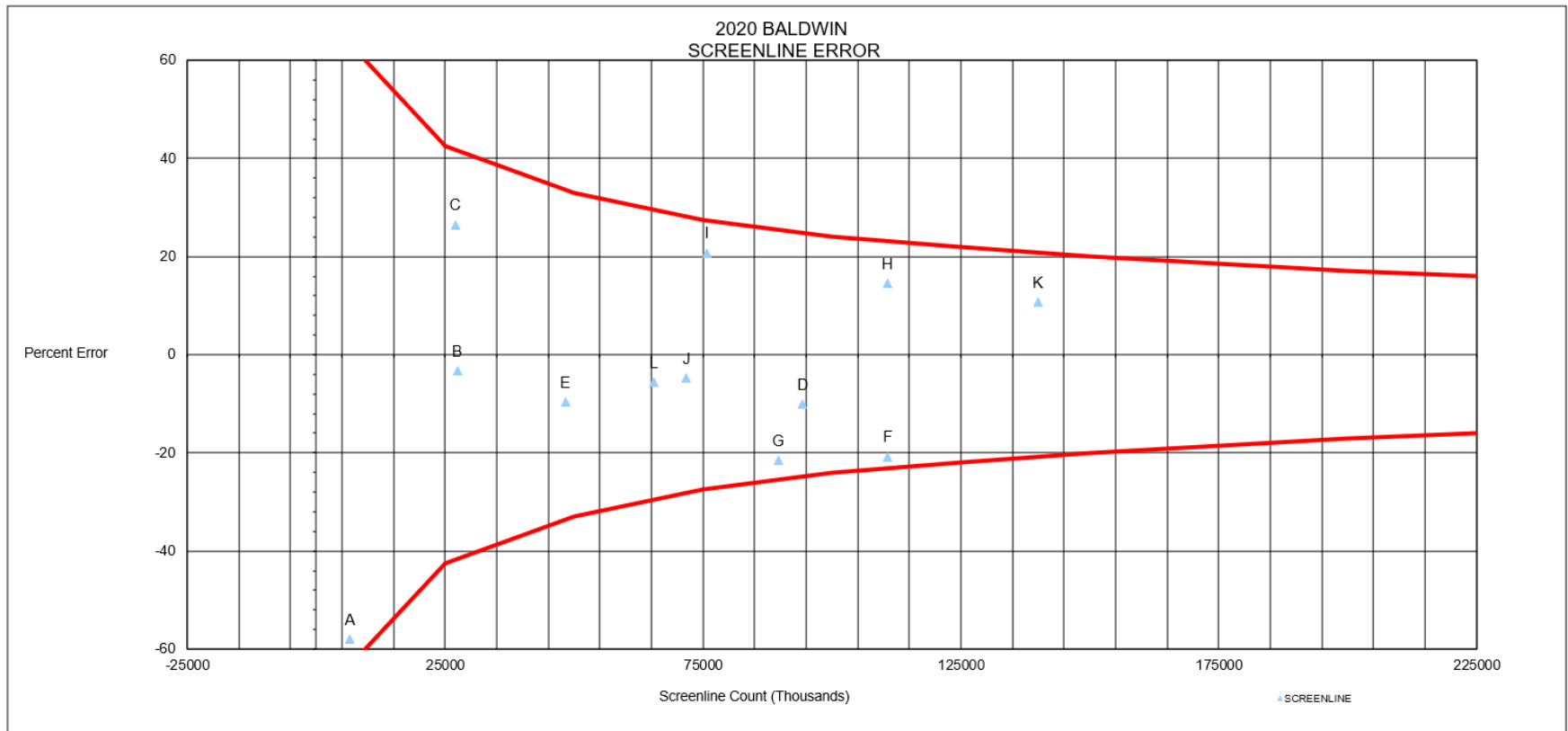


Figure 19 Screelines of Baldwin County

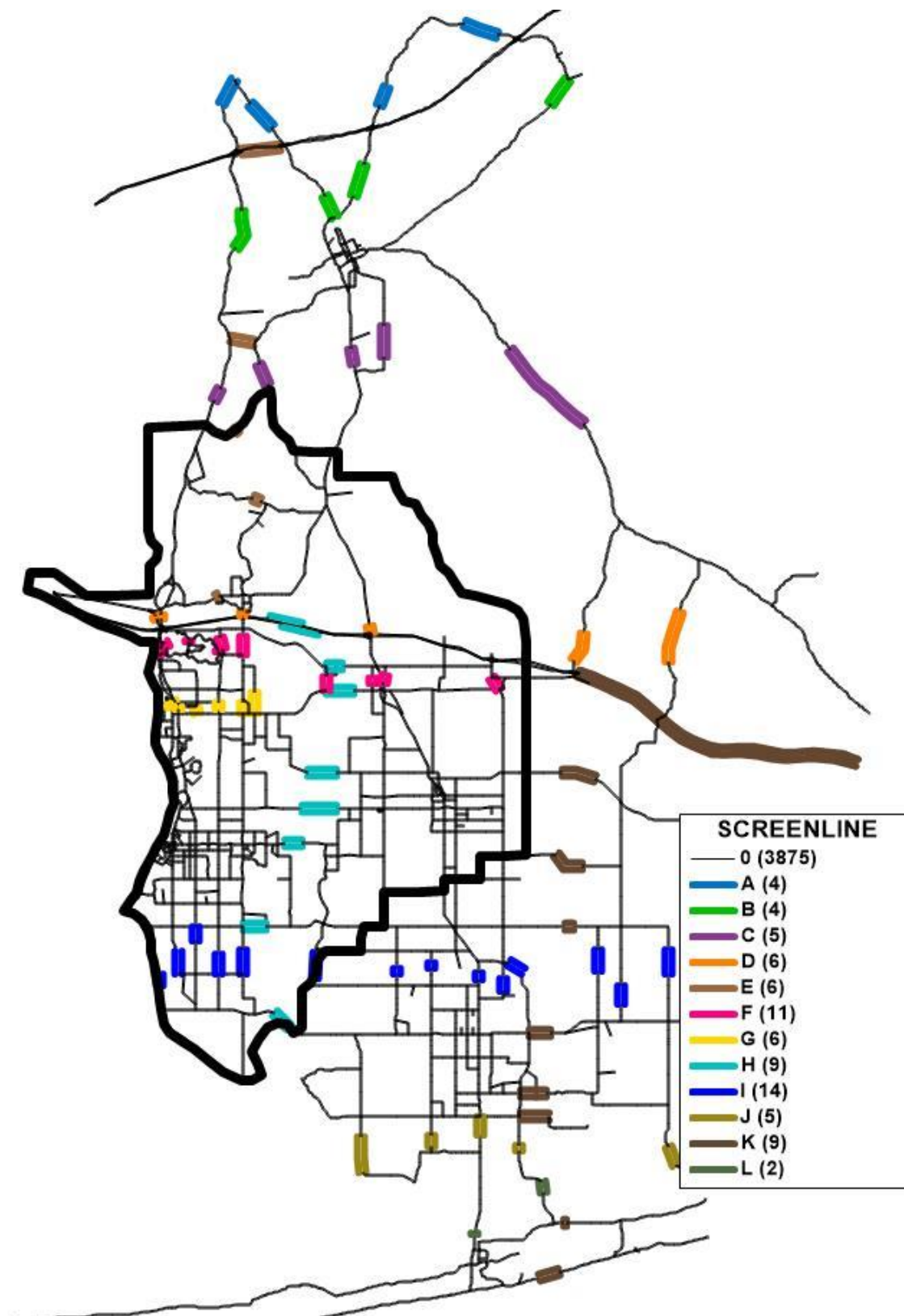


Figure 20 RMS Error by Functional Classification

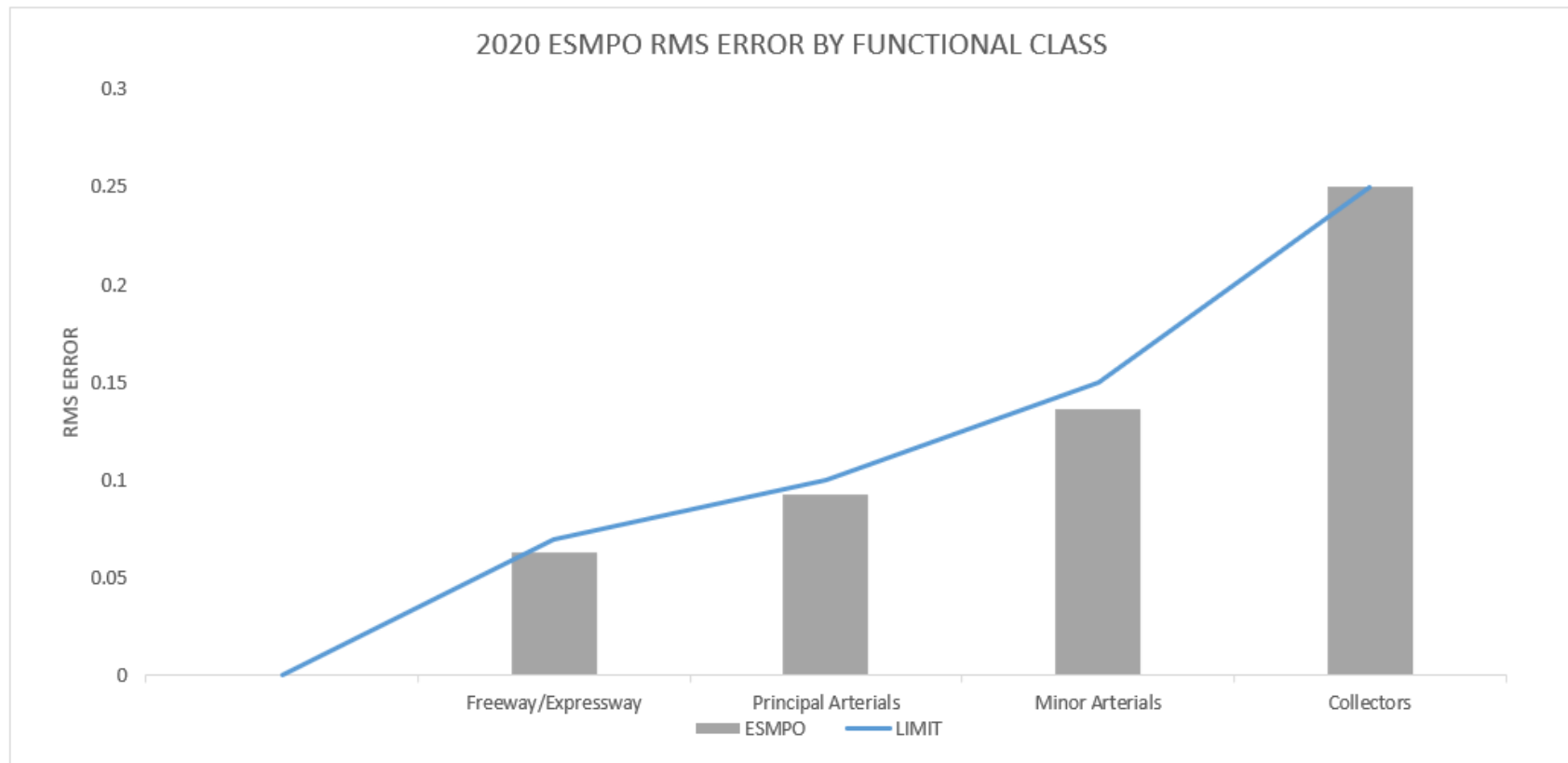
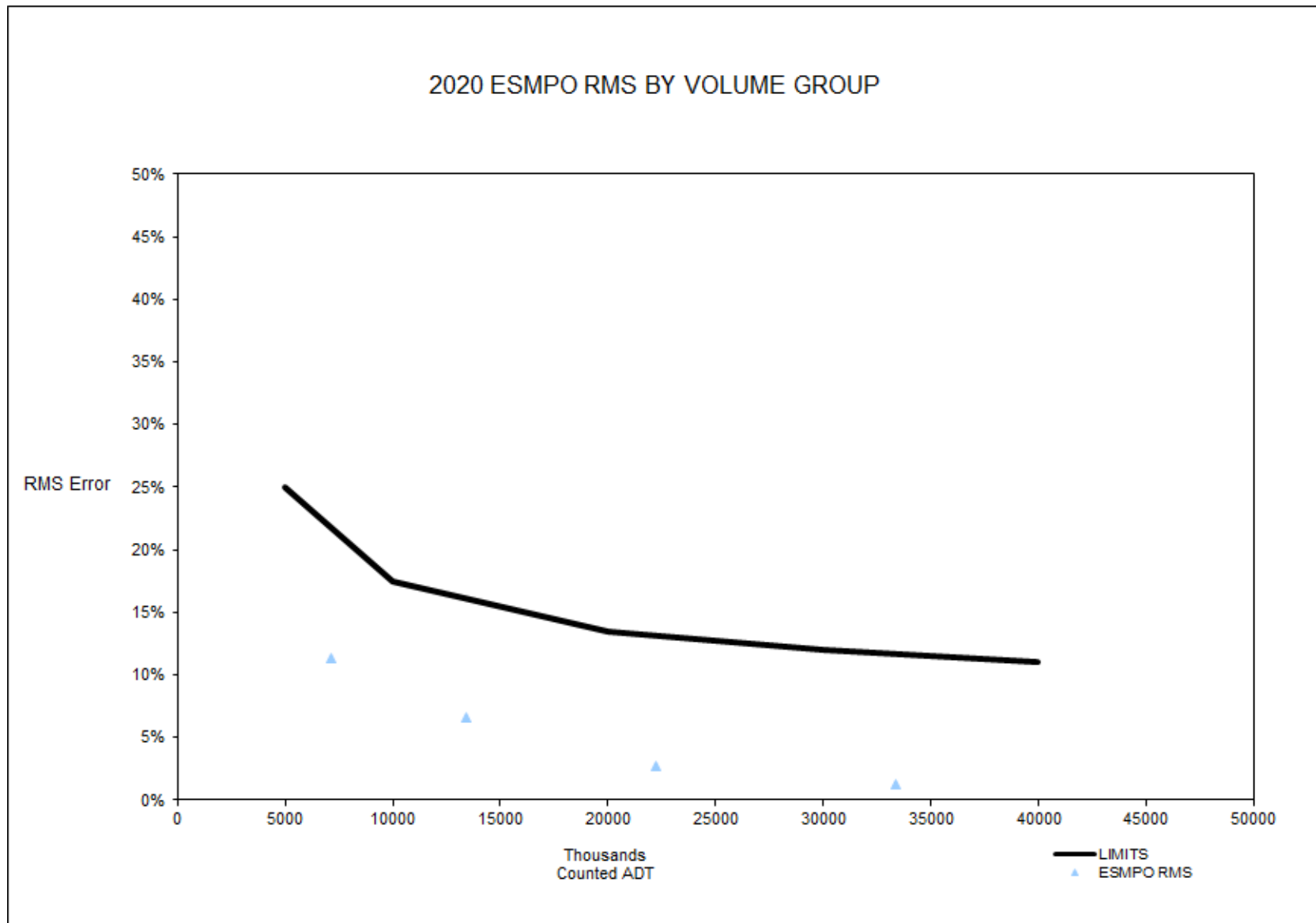


Figure 21 RMS by Volume Group



Every model has its own anomalies; Baldwin County is no different. Baldwin County has parallel interstates, I-65 and I-10, which affected the validation of the base year network. The model understands each of these interstates has a large external production and attraction value as they have a rather high traffic count. Those that travel down I-65 traveling south, would not take SR-225 to get to the Bayway. That is illogical, however the model does not understand that the interstates are connected in the Mobile County. This produced a high screenline error as the modeled volumes were exceptionally high compared to the traffic counts on SR-225. A K-factor had to be applied to control that movement. A K-factor is a rate applied in the origin\destination matrix to reduce (or increase) the number of trips between the pair. It is an “impedance factor” and does not hold the same meaning as a K-factor in traffic engineering. Trips making the trip pattern from or to I-65 North at the Escambia County Border and the Bayway (I-10) or the Causeway (US-90) at the Mobile County border were reduced until the screenlines B and C (Figure 19) were acceptable.

Foley Beach Express Toll

The Foley Beach Express (SR-161) in the base year had a toll facility included. This was modeled as an impedance of speed and capacity until validation was reached (model produced similar volume to AADT) across the intrazonal canal. The capacity and speeds are in Table 3 and 4. The toll impedance is not present in the future (No-Build) network.

K-Factor effects on the Bayway

This resulted in reducing the number of trips from the two external zones, I-65 N and I-10 E (the Bayway). Table 9 shows the external counts that were input into the model; however, the resulting external volumes were reduced due to the K-factor being applied. Screenlines B and C had to be correct in order to validate the model. This was at the cost of lowering the resulting volumes on the Bayway and the Causeway. Caliper Corporation (through technical support of TransCAD) suggested we would have to choose between validated screenlines B and C and lowered Bayway volumes, or correct Bayway volumes with overloaded north to south movements.

Seasonal Trip Origins and Destinations

It should be noted that in order achieve validation on Pleasure Island (Gulf Shores and Orange Beach) households had to be artificially supplemented because of seasonal traffic. There are only two bridges crossing the intracoastal canal into Orange Beach and Gulf Shores. Because of season traffic and having to validate the model to observed traffic counts, 2,700 households were artificially added to Gulf Shores and Orange Beach to achieve validation. There were several other methodologies discussed to achieve validation, artificially adding households seemed the most logical. This methodology was used for employees (attractions) as well. Fort Morgan Road has a higher AADT count than the model was producing for the number of employees and residents in the base year socio-economic data.

Although the traffic counts were conducted in February 2021, there was still traffic from vacationers that would not be counted in the “household” census count. Some TAZs at the beach have over 5,000 housing “units”. These are not “households” as defined by the US Census. A household is a housing

unit occupied by a permanent resident. If validation of the model were to be done to summer traffic counts, a different methodology would have to be used to model seasonal traffic.

External Volumes

External volumes (Table 9) are those volumes that are on the roads that cross the Study Area Boundary. The 2021 volumes are actual Average Annual Daily Traffic Counts provided by ALDOT, and the 2050 Volumes were provided by ALDOT. Most of the 2050 volumes were included in the count file provided by ALDOT, with the exception of the Bayway and Causeway. I-10 West (Bayway) and US-90 (Causeway) are reflective of the year 2050 with a toll and match the Mobile MPO travel demand model.

Table 9 External Stations

<u>External Station</u>	<u>2021</u>	<u>2050</u>
I-10 West	66,021	72,699
US-90	26,709	61,667
SR-180	18,326	22,358
US-98	14,209	19,140
US-90 E	5,381	7,393
I-10E	36,852	47,723
CR-112	1,241	1,514
Barrineau Park RD	672	820
US-31	5,409	6,268
CR-47	875	2,888
I-65E	26,382	35,245
AL-225	1,501	2,575
I-65W	23,768	45,913

Figure 22 K-Factor on SR-225



Future Year Data

Population

In order to understand the future population of the Baldwin County, a county wide population projection first had to be agreed upon. According to the US Census, the 2020 population for Baldwin County was 231,767. However, the Baldwin County travel demand model does not include the entire county, yet everything south of SR-225. The population for the Baldwin County 2020 travel demand model is 226,974. Population forecasts were developed for Baldwin County using a variety of standard methodologies, and numerous discussions occurred as to what the 2050 population for Baldwin County should be. The future population data for the Baldwin County TDM is based on county wide year 2050 projections disaggregated to the Traffic Analysis Zone (TAZ) level. A lot of thought and discussion went into the year 2050 Baldwin County population estimate. Numerous methodologies of trend analyses were discussed with the Baldwin County Economic Alliance, MPO staff, and the Baldwin County Engineering Department. It was finally agreed on the year 2050 population estimate for Baldwin County will be 488,000 using an exponential forecast. Figure 23-25 depicts the various forecasting methodologies considered.

The exponential forecasting methodology in Figure 25 was used to determine the future population for year 2050. This forecasting methodology was used for employment as well as households. Table 6 on page 22 is the base year and future year demographics for the Baldwin County Travel Demand Model. Once the total population, number of households, and employees (retail and non-retail) were established for the future year 2050, the socio-economic data was disaggregated to the TAZ level. The disaggregation of households and employment was done at the TAZ level using growth rates. Each TAZ has its own unique growth rate.

Growth Rates for 2050 Socio-Economic Projections

The growth rates are discussed in the 2050 Long Range Transportation Plan. There is not a single growth rate per TAZ as there are dynamic formulas per TAZ. Each of the 592 internal TAZs of the Baldwin County Network has a variety of data tied to it. Each TAZ has its own unique growth rate based on land cover, flood plain, proximity to arterials, historic trend analysis, percent residential versus commercial, growth recommendations from the County, etc. To prevent wetlands, recreational areas, and existing developed areas from being allocated additional households or employment, developable property was established per TAZ. Satellite imagery and ESRI products were used to calculate the percentage of undeveloped property per TAZ. The undeveloped areas of each TAZ where development was not allowed (flood plain, protected areas, parks, cemeteries, etc.), was omitted from the percentage of developable property per TAZ. Data from the 2022 Baldwin County Broadband Study (Figure 28), conducted by Sain Associates, was highly beneficial in creating a comprehensive database detailing each commercial and residential structure throughout the county. Each TAZ has an existing commercial / residential ratio. Finally, the growth rate of each TAZ had a slight gravitation pull to the principal arterials (Figure 29). That is to say, the rural TAZs with the majority of roads being functionally classified as local and collector, did not have as much growth estimated as more urban TAZs.

Comprehensive Plans

The growth rates per TAZ are a starting point for the projection of growth. The various comprehensive plans were also used for reference. Spanish Fort, Daphne, Fairhope, Loxley, Gulf Shores, Foley, Orange Beach, and Baldwin County were reviewed and respective jurisdictional adjustments were made. Some of the Comprehensive Plans have an estimated “future year build out”, and some Comprehensive Plans have nodes of that should be given more consideration than other areas within their Comprehensive Plan while, some comprehensive plans have future projects listed. The Baldwin County Planning Department reviewed the data projections and offered “nodes” of consideration for growth within Baldwin County. Several new developments were considered to include Caribe Seaside, Solis Condominium, Phoenix Key, Springhill Suites hotel, Tapestry Orange Beach, ABACO Orange Beach, Lost Bay Town Homes, and Phoenix South Point.

Households

According to the 2020 US Census, the number of occupied housing units, or households, in all of Baldwin County was 93,116. The number of households south of SR-225 and SR-59 were 91,073. For the purposes of the Baldwin County travel demand model, the area of Baldwin County south of SR-225 had 93,782 households. In order to forecast the households for the future year in Baldwin County, growth rates (discussed later) and persons per household were calculated to create an estimated future number of households in Baldwin County. Figure 26 is a combination of polygons from USGS and Federal Flood Plain maps to assist in projecting developable land. Figure 27 is from the Baldwin County Master Plan that was used in consultation with the Baldwin County Planning Department as to which areas of the County to concentrate growth. Baldwin County staff also provided plat data from 2018-2024 that helped produce a trend analysis, mainly for the Eastern Shore of Baldwin County. The Baldwin County estimated households in year 2050 are 199,415, as compared to the base year of 93,782 households.

Employment

The 2050 employment estimate used the same accepted population forecasting formula (Figure 30). The model’s trip attractions are based on employment totals in retail and non-retail employment projections. Future retail and nonretail employment data for year 2050 had an original number of employees disaggregated to the TAZ as a starting point. However, those future employment numbers were further refined to include known future employment centers. This is to include the Port of Alabama, the Daphne Technology Center, future schools, and other prime retail potential locations. Further, the Baldwin County Planning Department suggested areas to concentrate on, “nodes” in the area to pay attention to. The number of retail employees in 2050 is estimated to be 44,656 as compared to the base year of 26,649. The number of non-retail employees in 2050 is estimated to be 133,970 as compared to the base year of 80,479.

Figure 23 Examples of Population Forecasting Methodologies

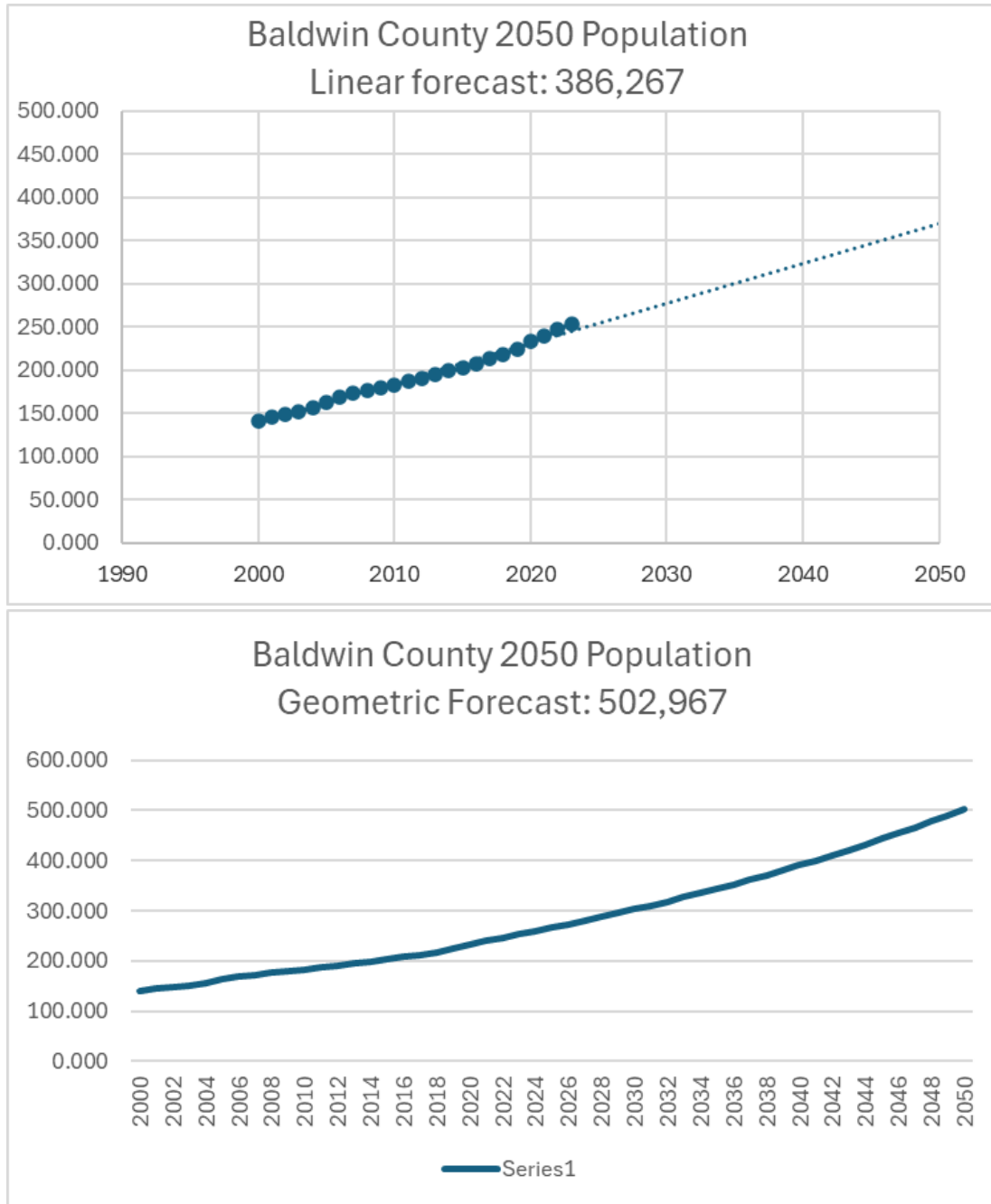


Figure 24 Examples of Population Forecasting Methodologies

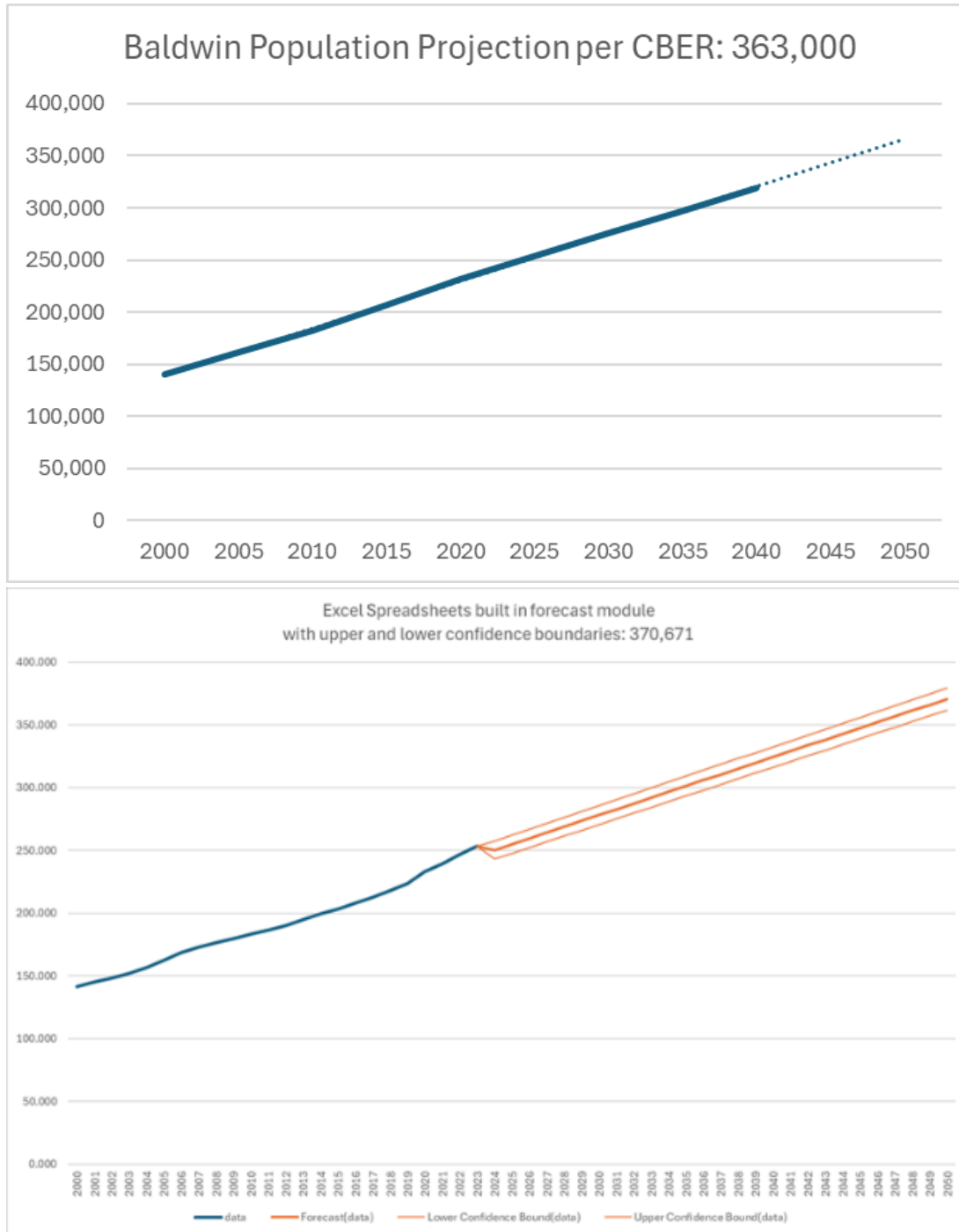


Figure 25 Examples of Population Forecasting Methodologies

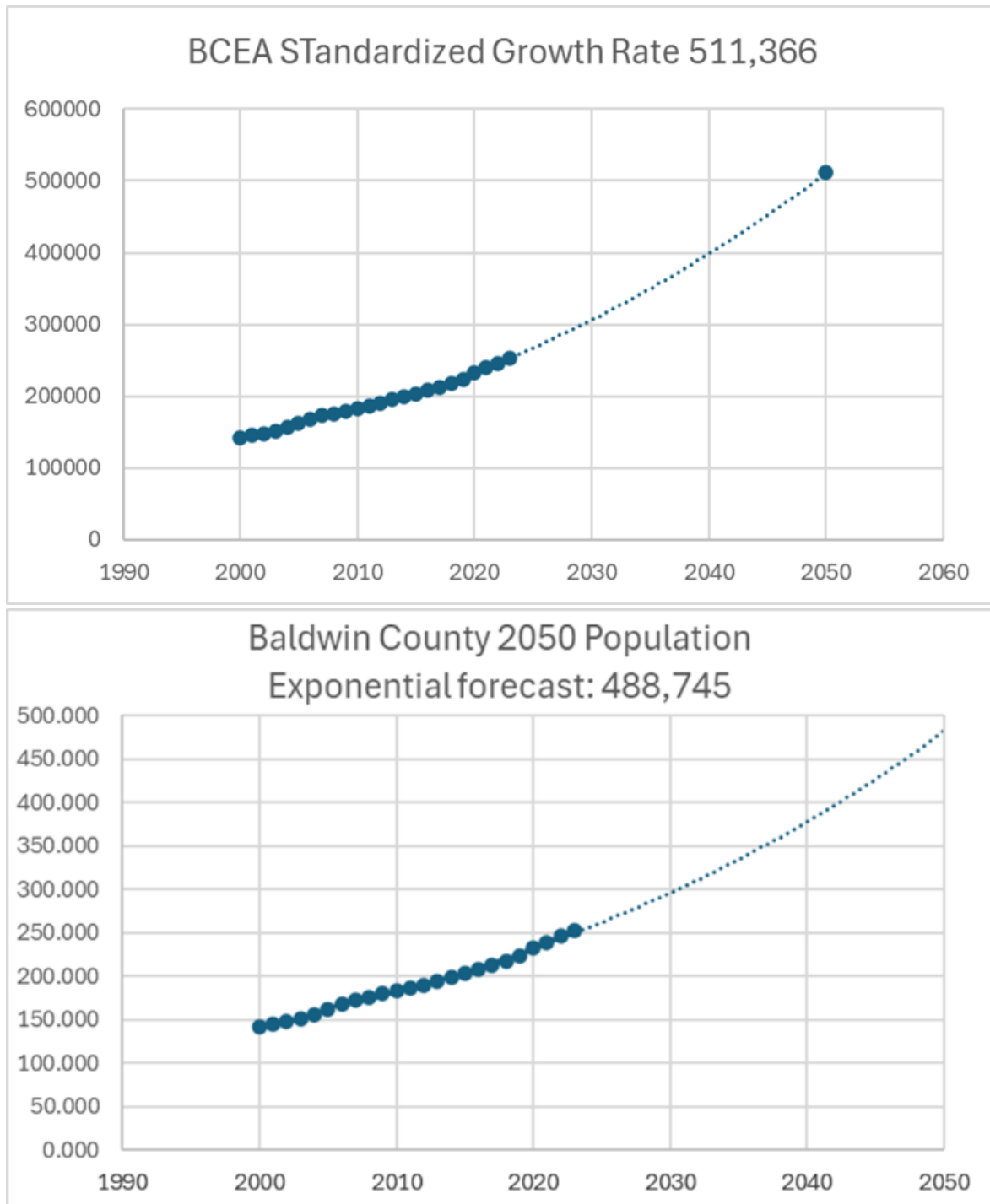


Figure 26 Land Cover and Flood Zones

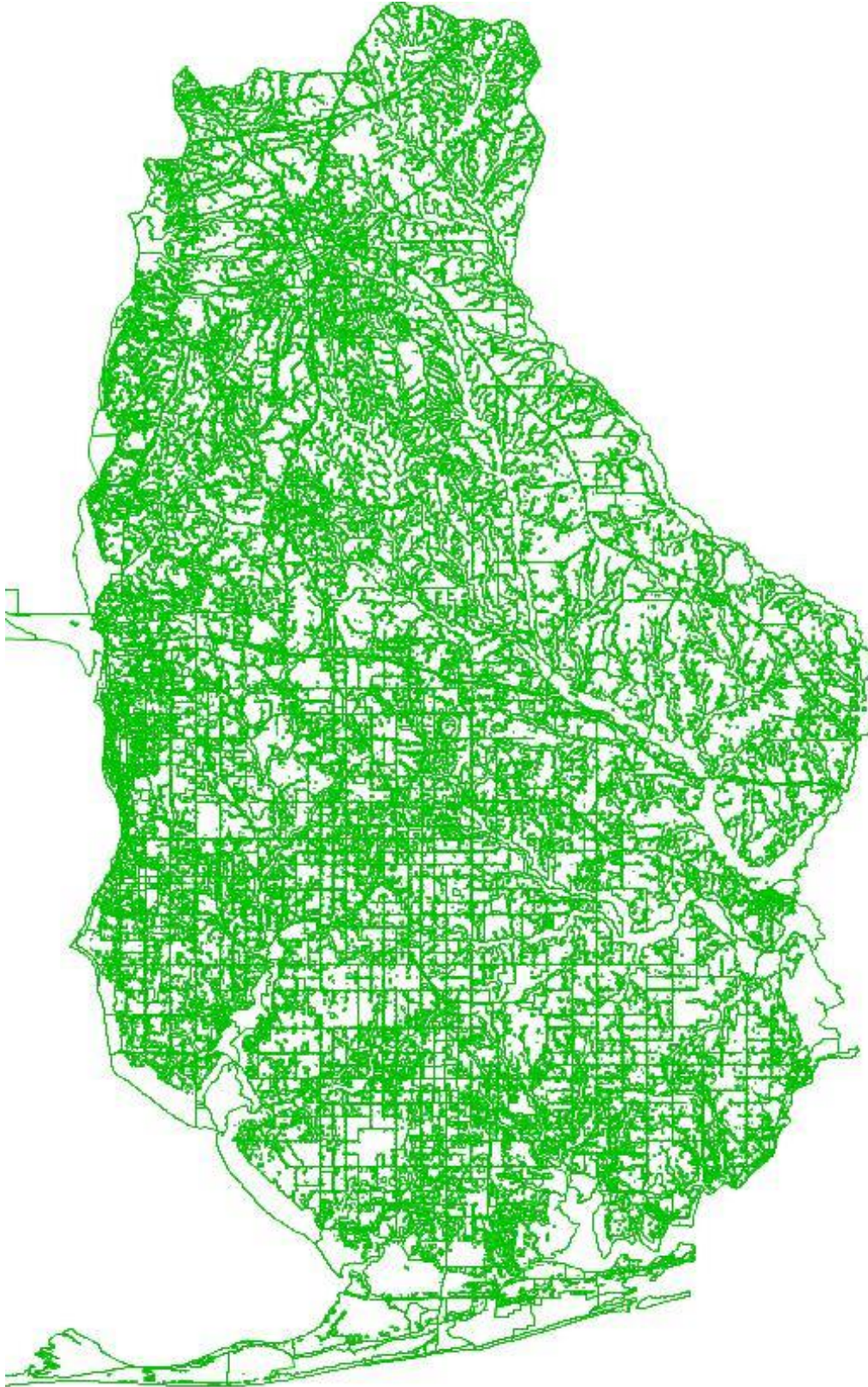
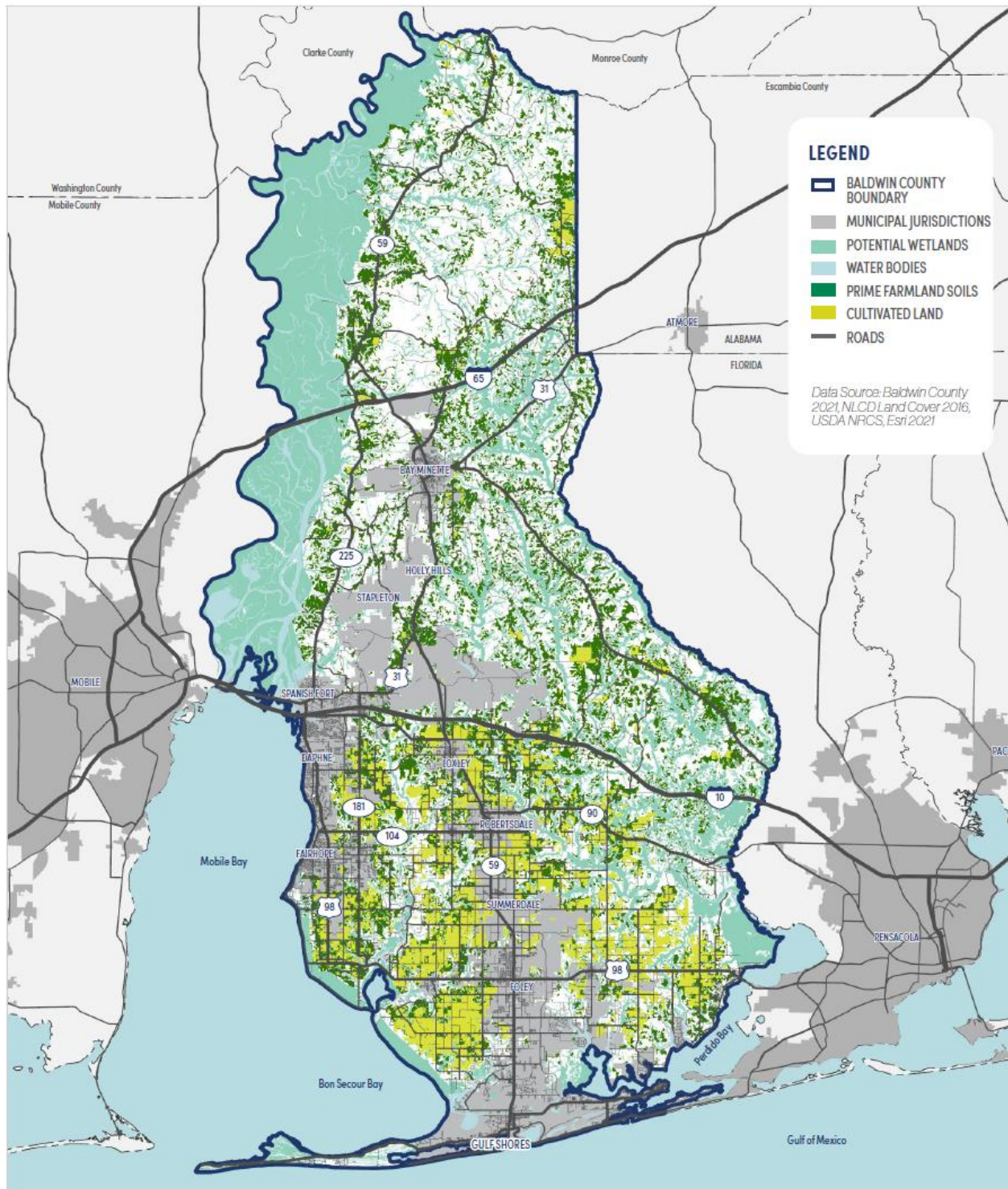


Figure 27 Guide to Growth



(source: A Citizen's Guide to Growth in the Zoned Areas of Baldwin County)

Figure 28 Commercial and Residential Structures

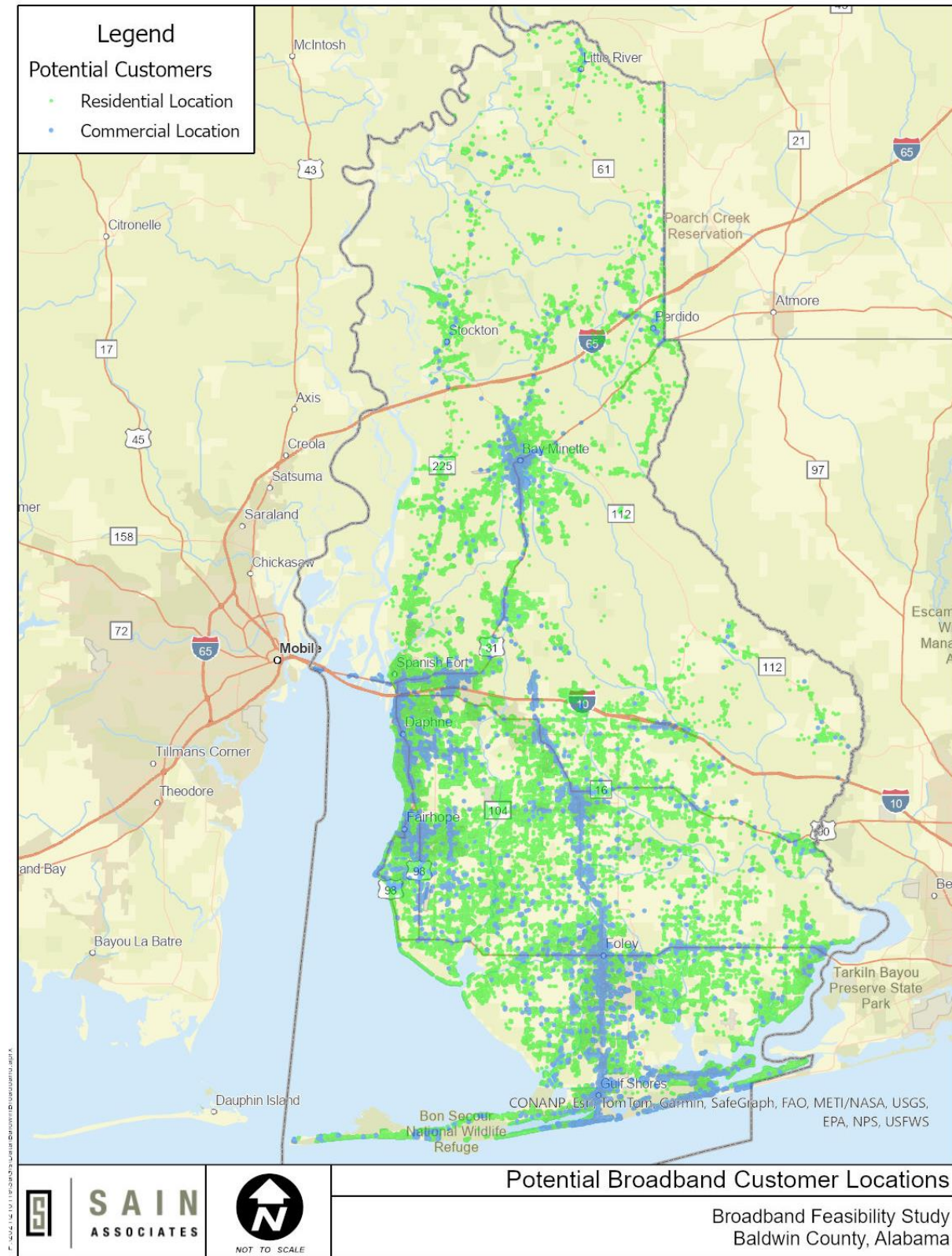


Figure 29 Buffer from Principal Arterials

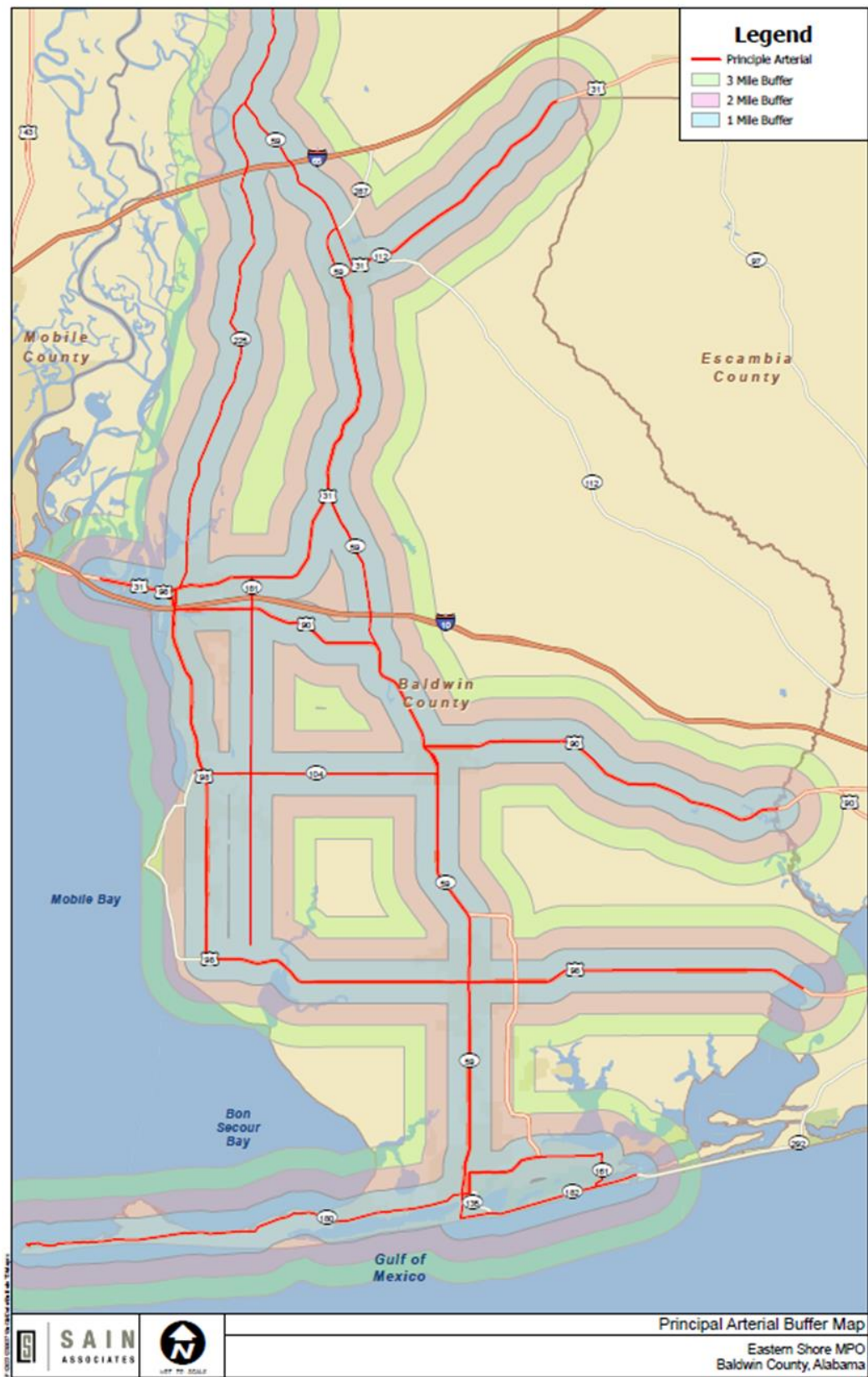
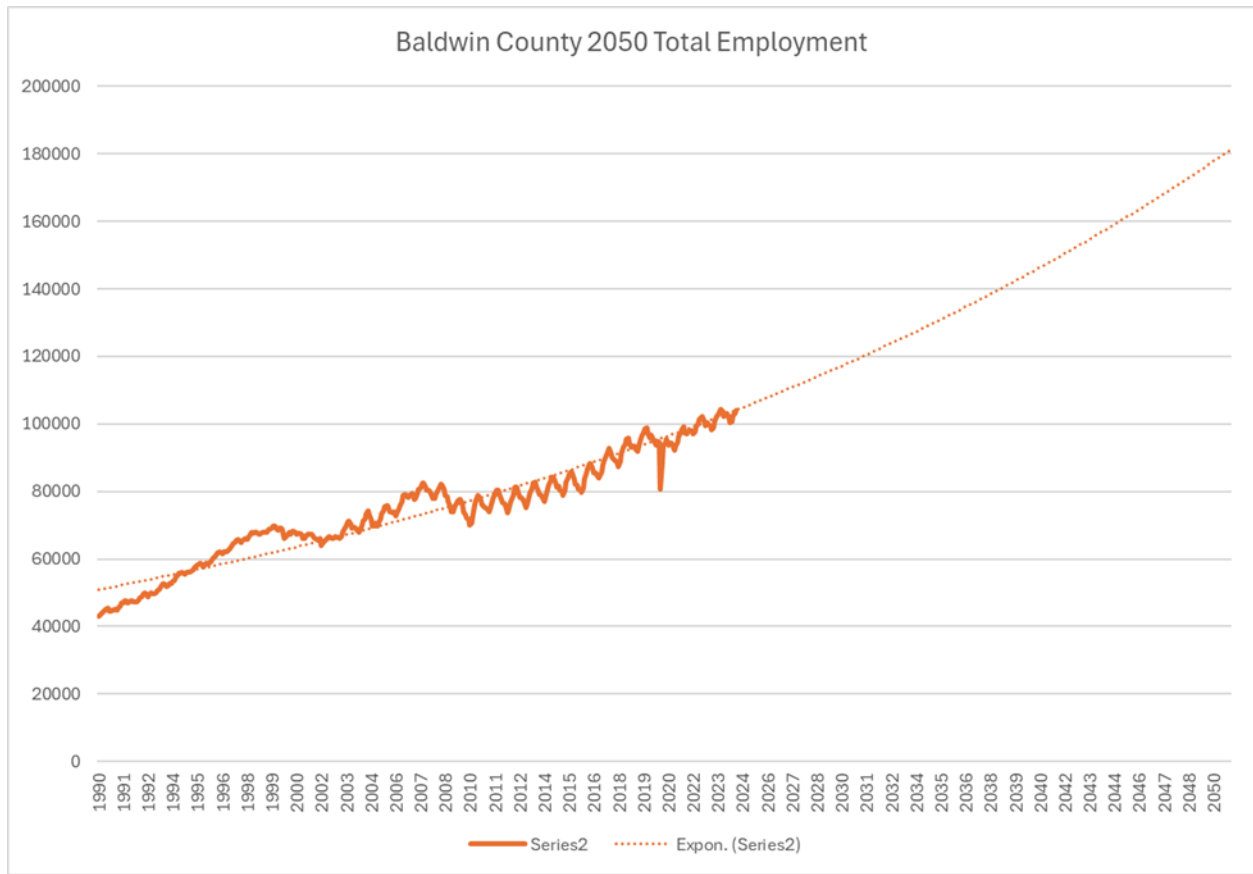


Figure 30 Baldwin County Future Employment



Quality Control

Volkert, Inc. conducted a quality control (QC) check on the socio-economic data and zonal structure of the Baldwin County network. The findings were detailed and included items that were legacy issues from the previous Cube migration. Typically, these were items like the zonal structure of the TAZs. The QC was discovery of TAZ population issues, TAZ household issues, check of average population per household, employment per acre (checks against more than 10 employments per acre). The QC also checked the 2020 total Pop, HH, HH Per Sq Mile, and Employment for Baldwin County, and those values are in line with the overall totals from the spreadsheet.

Figure 31 Future Households by TAZ

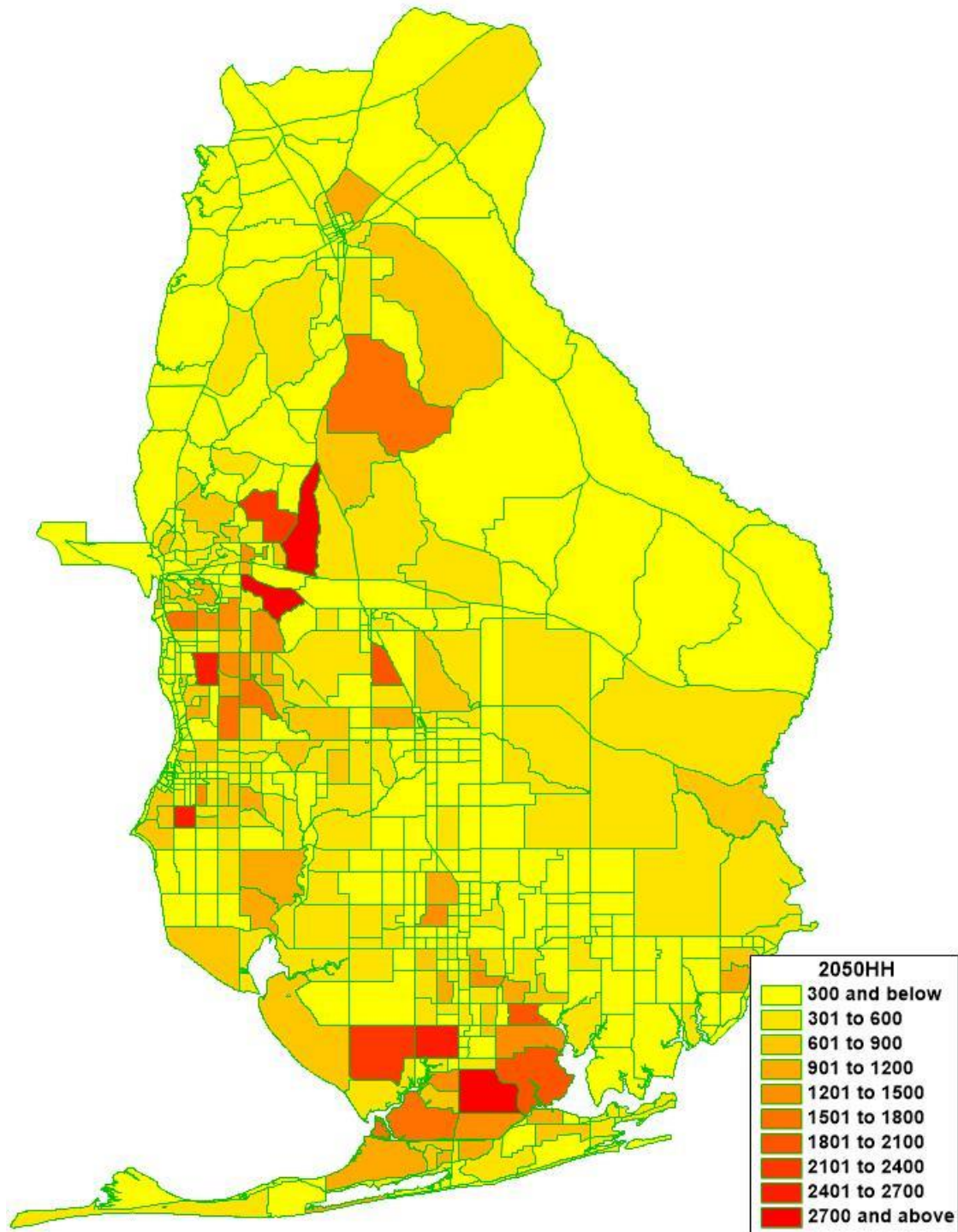


Figure 32 Future Retail Employment by TAZ

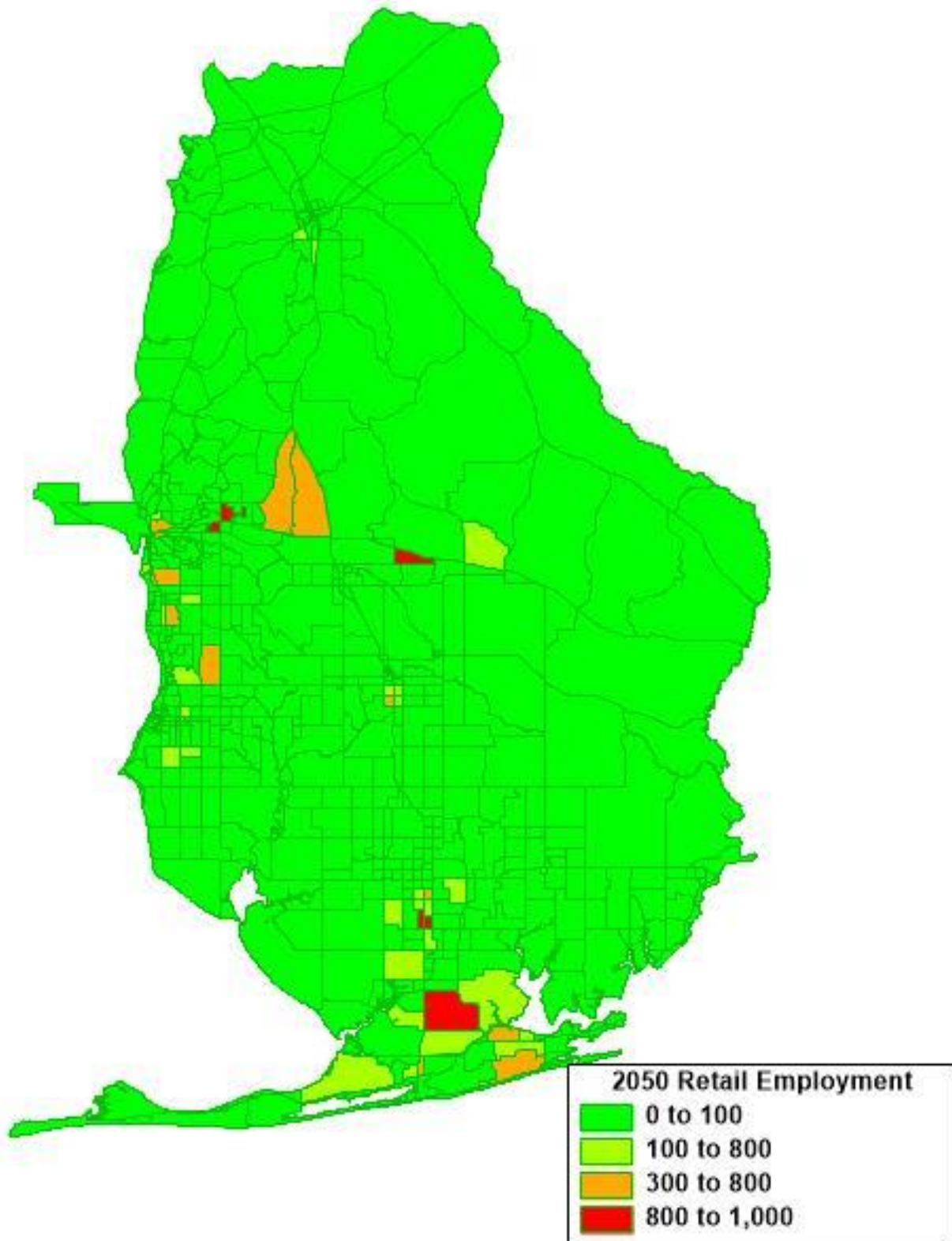
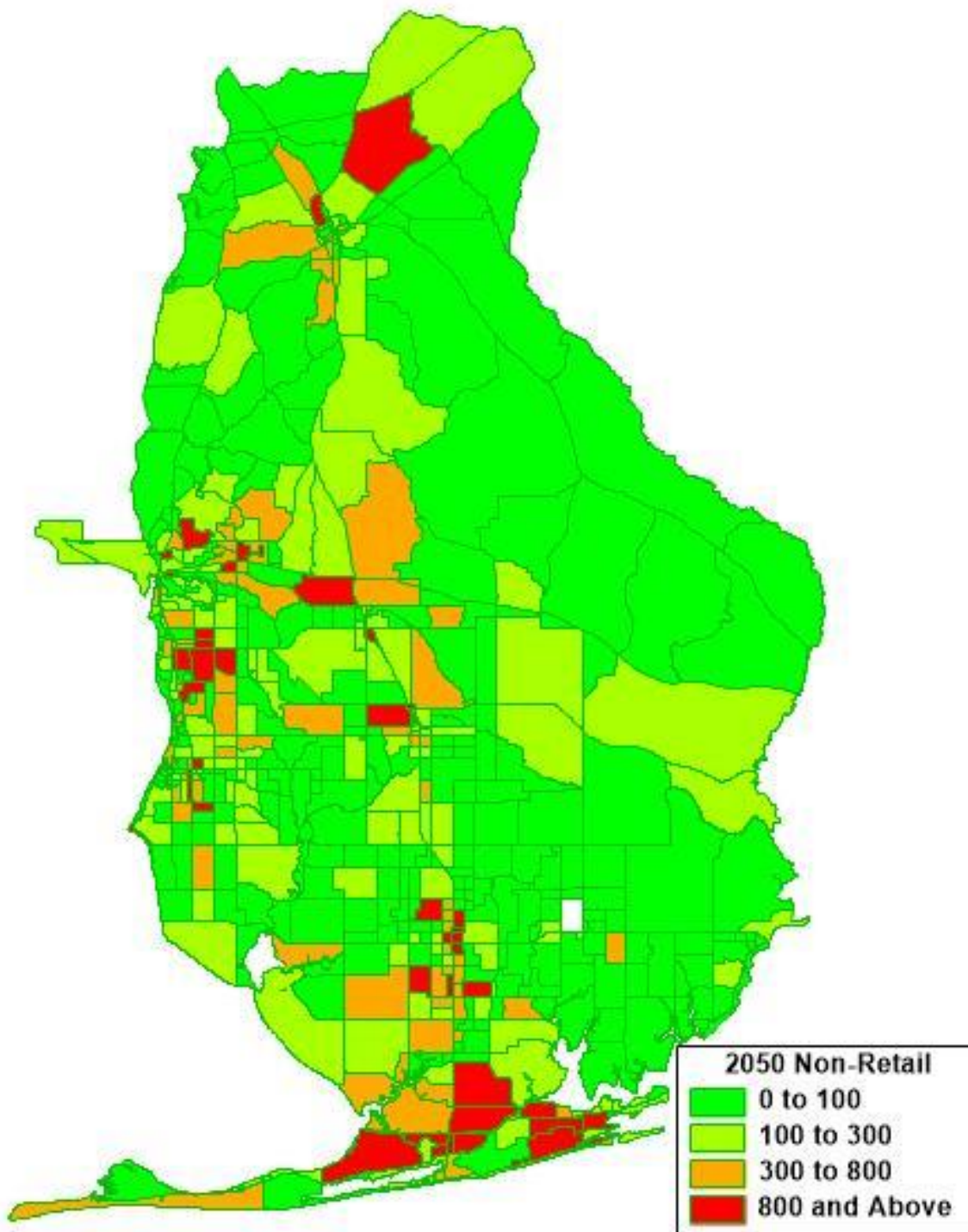


Figure 33 Future Nonretail Employment by TAZ



No-Build Network

Coupled with future external traffic volumes, the Existing and Committed (No-Build) network (Figure 34) is the existing base year 2020 network with the future 2050 socioeconomic data as the input. The year 2050 traffic volumes at the external stations (at the Baldwin County line) for each functionally classified road was provided by ALDOT. This produces future year volumes on the existing network and assumes that from the base year to the future year there will be no infrastructure improvements. Although not practical in thinking there will be no improvements in the next 30 years, this is a standard method of a control for building travel demand forecast models, also called the “No-Build” network. The No-Build network gives a snapshot of the future traffic congestion. Figure 34 shows the level of service of the 2050 No-Build network. The Existing and Committed network is the starting point for Baldwin County to test future projects.

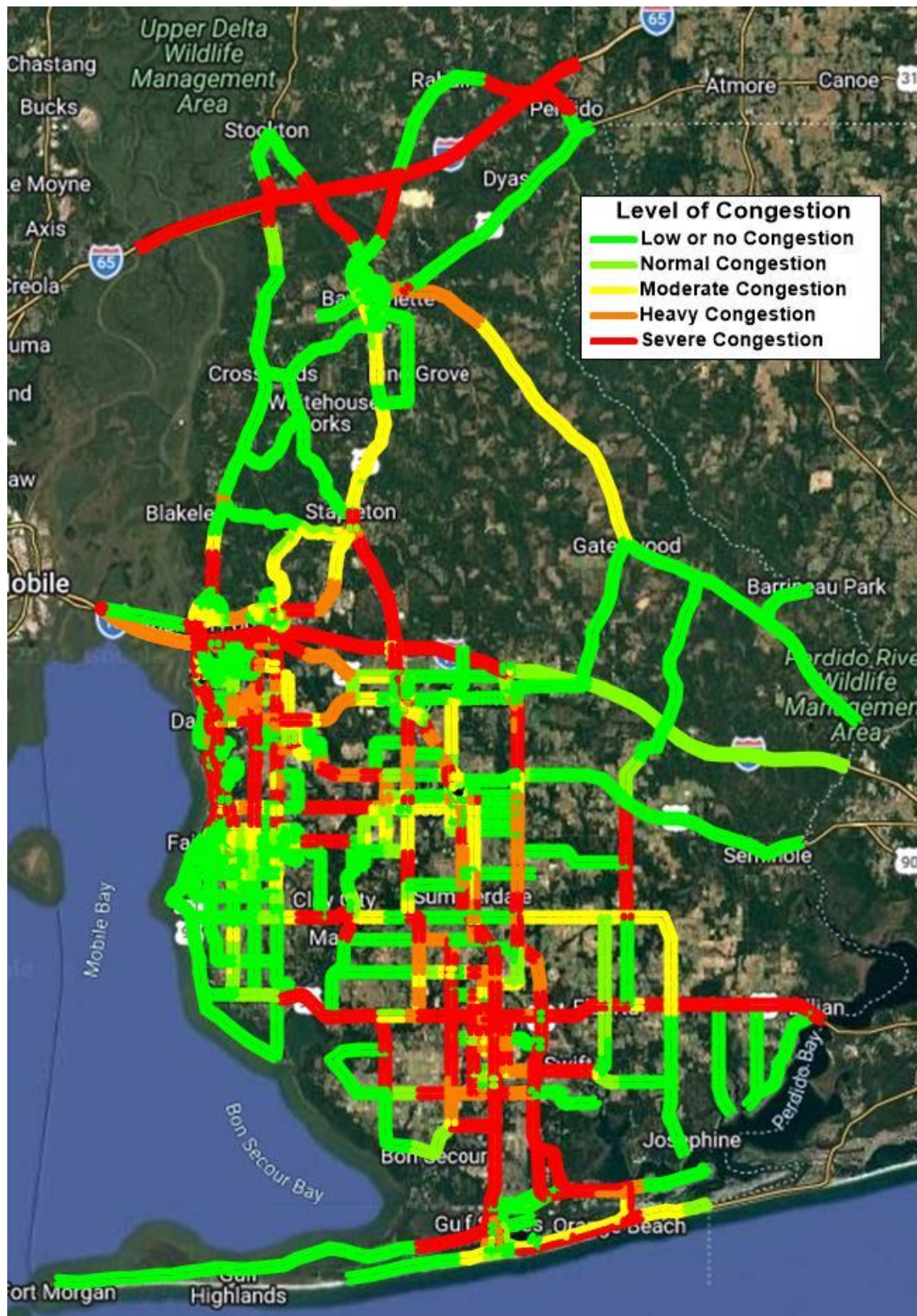
Conclusions

The 2050 future year No-Build model shows that the majority of State Routes in Baldwin County will have future capacity issues. This is to include both interstates, SR-59, SR-161, US-98, US-90, and SR-104. Further, CR -13, SR-181, US-90, and SR-104 on the Eastern Shore are anticipated to have severe congestion in year 2050.

In southern Baldwin County and Foley, there is a strong attraction that is pulling trips from the interstates and other parts of the County. This coupled with the growth trends in Baldwin County, anticipate severe congestion in Foley, Gulf Shores, and Orange Beach in the future year. The Foley Beach Express one-way pairs are anticipated to be slightly over capacity in year 2050. This showed a great increase from the base year (2021) as this road had a toll.

The Baldwin County Travel Demand Model in TransCAD is an extremely useful tool as Baldwin County now has the ability to test future infrastructure projects. Road widenings, future alignments of roadways, additional capacity projects, can all be tested. The model can be used to help predict how people will travel in Baldwin County in the future, and help simulate the relationship between transportation, land use, and economic growth to guide long-term planning and investment decisions for all of Baldwin County.

Figure 34 Future Existing and Committed Network



Appendix A:

Terms and Acronyms for Baldwin County Model Documentation

Appendix A: Terms and Acronyms for Baldwin County Model Documentation

AADT: Average Annual Daily Traffic

ALDOT: Alabama Department of Transportation

CAD: Computer Aided Design

CFR: Code of Federal Regulations

DOT: Department of Transportation

EE: External/External

ESMPO: Eastern Shore Metropolitan Planning Organization

ESRI: Environmental Scientific Research Institute

ETS: Environmental Technical Section

FF: Friction Factors

FHWA: Federal Highway Administration

FTA: Federal Transit Administration

FY: Fiscal Year

GIS: Geographic Information System

HBW: Home Based Work

HBO: Home Based Other

IE : Internal /External

LRTP: Long-Range Transportation Plan

MPA: Metropolitan Planning Area

MPO: Metropolitan Planning Organization

NHB: Non Home Based

NHS: National Highway System

STIP: Statewide Transportation Improvement Program

TAZ: Traffic Analysis Zone

TKT: Truck and Taxi

USC: United States Code

V/C: Volume to Capacity